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VIRGINIA GEOLOGICAL SURVEY

UNIVERSITY OF VIRGINIA

THOMAS LEONARD WATSON, PH. D.

DIRECTOR

Bulletin No. VII

Geology of the Gold Belt in the James River Basin Virginia

BY STEPHEN TABER

ASSISTANT GEOLOGIST

CHARLOTTESVILLE

UNIVERSITY OF VIRGINIA

1913

J. P. BELL COMPANY
INCORPORATED
Printers
Designers
& Engravers
Lynchburg, Va.

Science

STATE GEOLOGICAL COMMISSION

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Director of the Survey.

CONTENTS

ILLUSTRATIONS

LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, 1913.

To His Excellency, Hon. Wm. Hodges Mann, Governor of Virginia, and Chairman of the State Geological Commission.

Sir:—I have the honor to transmit herewith for publication as Bulletin No. VII of the Virginia Geological Survey Series of Reports, a report entitled "Geology of the Gold Belt in the James River Basin, Virginia," by Dr. Stephen Taber, Assistant Geologist on the Virginia Geological Survey.

This report is the first of a series planned by the State Survey to cover the geology of the entire gold belt in Virginia, and it should prove of much value to those seeking information on the gold deposits of the area mapped and studied, including the counties of Buckingham, Cumberland, Fluvanna, and Goochland.

Respectfully submitted,
THOMAS L. WATSON,
Director.

GEOLOGY OF THE GOLD BELT IN THE JAMES RIVER BASIN, VIRGINIA

BY STEPHEN TABER.

INTRODUCTION

This report is a geologic and economic investigation of the Gold Belt in the James River Basin, Virginia, an area comprising 700 square miles in Fluvanna, Goochland, Buckingham, Cumberland, Powhatan, and Amelia counties. The occurrence and origin of the gold, copper, and sulphide deposits within the area are discussed in detail. The commercial slates of the area, while of great economic importance, are only briefly mentioned in this report as they will be considered at length in Bulletin No. X, now in course of preparation by the Virginia Geological Survey.

The field studies which form the basis of this report were made by the writer during June, July, and August, 1910, and July and part of August, 1911.

No attempt has been made to evaluate individual mines or to determine whether they can be operated at a profit, as that is properly the work of the consulting mining engineer and geologist; but such basic problems as the origin and distribution of the ore deposits, and their probable variation in depth—problems which can not be solved by the examination of a single property, or without the expenditure of much time and effort—have been investigated as fully as conditions would permit.

Acknowledgments.—The writer desires to thank Dr. Thomas L. Watson, State Geologist, under whose supervision the work was done, for the privilege of studying the area, and for his valuable advice and kindly assistance in the preparation of this report. He also wishes to acknowledge the many kindnesses shown him by the different operators in the district, and by others who aided him in the field investigations.

The topographic map of the gold belt in the James River basin (Pl. I) is compiled from the Palmyra, Farmville, Buckingham, and Appomattox sheets of the United States Geological Survey, with corrections inserted by the writer. The traverse maps, used as a base for the detailed geologic work, were compiled chiefly from surveys made by the writer. Control for the detailed map of the gold belt on the north side of James River (Pl. II) was furnished by the United States Geological Survey and the Chesapeake and Ohio Railroad, and for the Arvonia-New Canton map (Fig. 2) by the Chesapeake and Ohio Railroad. Other acknowledgments are made in the body of the report.

CHAPTER I.

GEOGRAPHY AND HISTORY.

LOCATION.

The district described in this report is situated a little east of the geographic center of the State, and lies on both sides of James River, about 60 miles above Richmond. It comprises the southeastern part of Fluvanna County, most of the western part of Goochland County, the northern three-fourths of Cumberland County, and adjacent portions of Buckingham, Powhatan, and Amelia counties, Virginia. The exact location is shown in the index map, fig. 1, and a large topographic and geologic map of the area is given on Pl. I, which will be found in the pocket at the back of the book.

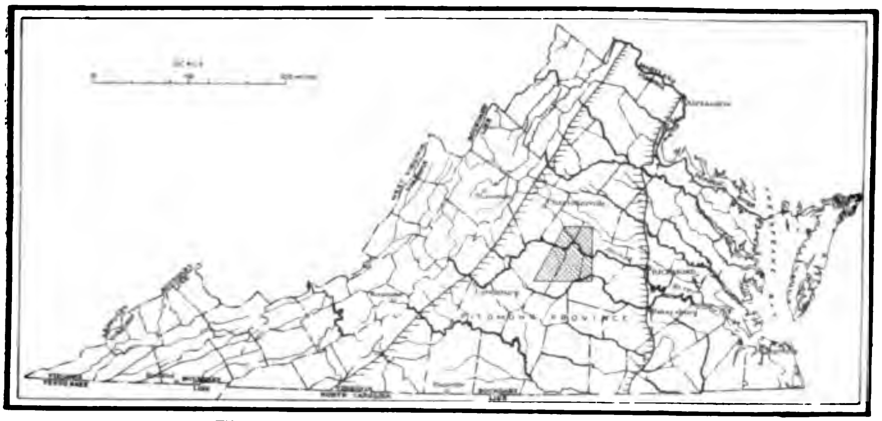

Fig. 1.—Index map showing location of area.

The area is trapezoidal in shape, being 30 miles long in a north and south direction, with a width of 15 miles at the northern end and over 32 miles along the southern boundary. It covers approximately 705 square miles.

The greater portion of the district is easily accessible from stations on the various railroads that cross it. The Chesapeake and Ohio Railway, following the north bank of James River, crosses the north central portion of the area in an east and west direction, while the Buckingham Branch of the Chesapeake and Ohio and the Virginia Air Line railways approxi-

mately parallel the western boundary, the former extending south from Bremo Bluff to Rosney, its terminus near the southern line, and the latter running from Strathmore northeast to Carysbrook and thence northward approximately parallel with Rivanna River. The Tidewater and Western Railway, a narrow gauge line, crosses the southeastern corner of the area.

With reference to the major physiographic divisions of the State, the area is located in the center of the Piedmont Plateau; it lies within the belt of old crystalline rocks that extends from New Brunswick to Alabama; and is a part of the gold belt in the Southern Appalachians region.

TOPOGRAPHY.

The topographic features of the gold belt present little by way of variation; the land surface is gently rolling, consisting of broad flat-topped hills or ridges and narrow valleys. The ridges are remarkably uniform in elevation, ranging from 450 feet above sea level along the eastern border of the area, to 550 or 600 feet in the western portion, and the valleys of the larger streams have an average elevation of about 225 feet.

The only variation in the monotony of the topography is furnished by Willis Mountain in the southwest corner of the area, which is the most prominent single feature of relief found in the State east of the outlying ranges of the Blue Ridge. It consists of a narrow ridge, about two miles long in a north and south direction, which rises abruptly from the Piedmont Plateau to a height of 1,159 feet above sea level, the upper portion being exceedingly precipitous and almost bare of vegetation.

DRAINAGE.

The area is drained by James River and its tributaries. James River flows directly across the area in a general easterly direction. Rivanna River and Byrd Creek are the principal streams entering James River on the north; and Slate River, Willis River, and Muddy Creek on the south. Appomattox River, flowing northeasterly, cuts across the southeast corner of the area and finally empties into the James below Richmond. Minor creeks and branches spread out from the principal streams, and completely drain all parts of the district.

The estimated mean yearly discharge of James River at Cartersville, where the drainage area is 6,232 square miles, is 8,189 cubic feet per second. These figures are based on daily observations taken between January 1, 1899, and December 30, 1905, under the direction of the Hydrographic Branch of the United States Geological Survey.[a] During

[a]Grover, N. C., and Bolster, R. H., Hydrography of Virginia, Bull. No. III, Geol. Survey of Virginia, 1906, pp. 142-152.

this period of seven years the maximum discharge for any single day was 97,800 cubic feet per second on December 15, 1901, and the minimum discharge for any single day 842 cubic feet per second on September 15, 1900.

SOIL.

The alluvial soils of the valleys, while limited in extent, are very rich; but the residual soils that cover the ridges are for the most part lean, and do not make first-class farming land. It was originally covered with a heavy growth of timber which has been greatly thinned out by cutting. All of the bottom lands and much of the uplands are at present under cultivation, but large areas of the latter have been allowed to grow up with a second growth of timber. While not naturally so rich as the bottom lands, much of this residual soil is capable, under proper farming methods, of a high degree of productivity.

CLIMATE.

The climate is equable and agreeable during the greater part of the year; the mean annual temperature is about 56° F., and the thermometer seldom drops as low as zero in the winter or reaches as high as 100° in the summer. The average yearly precipitation is about 42 inches, and this is quite evenly distributed throughout the year, so that prolonged droughts in summer or excessive rain and snow in winter are seldom experienced.

CULTURE.

The country is sparsely populated, and there are no large towns within the area. The chief industry of the inhabitants is farming, with corn and tobacco as the principal crops. Considerable lumbering is still carried on, and many railroad ties are shipped out of the district. Slate has been extensively quarried in Buckingham County for many years, and mining was at one time an important industry, but recently it has been carried on only in a spasmodic way. There are practically no manufacturing industries in this section, and although there is good water-power in certain localities it has as yet received little attention. Many of the smaller streams have been utilized to run saw mills and grist mills for local custom, but this is the extent of water-power development. Within the past few years great strides have been made in the public school system, and large new school buildings have been erected in nearly all of the towns.

HISTORY.

The early history of gold mining in the James River valley is so closely connected with the development of that industry elsewhere in Virginia, and indeed throughout the Southern Appalachians region, that a brief outline of the more important happenings in other parts of the gold belt will be given. The general history of the entire gold belt was summed up by J. D. Whitney[a] in 1854, and by Geo. F. Becker[b] in 1895.

According to Becker the first mention of gold in the Southern Appalachians states is by Herrera[c], and "is to the effect that on June 4, 1513, while Ponce de Leon lay near the southern end of the peninsula of Florida, he was informed that a cacique in the neighborhood had a quantity of gold." Several years later Spanish and French explorers refer to the possession of gold by the Indians; and Lemoyne, in his "Brevis Narratio"[d], of the journey made by Laudonnière in 1564, describes a method used by the Indians in separating gold from sands, which they found in rivers flowing from the Appalachian Mountains. Authorities differ as to how the Indians obtained their gold, but it seems probable that no systematic efforts were made by them to recover the metal. It can scarcely be doubted, however, that they found gold nuggets and made use of them, for in later years white miners found many large nuggets on the surface, some weighing several pounds, and such lumps must have been more plentiful before the country was settled. While the Spaniards are reported to have done some mining in Georgia in the seventeenth century, practically no systematic work was undertaken until after the beginning of the nineteenth century.

The earliest authentic reference to gold in Virginia is by Thomas Jefferson in 1782. He describes a lump of ore found on the north side of Rappahannock River about 4 miles below the falls. The gold "was interspersed in small specks through a lump of ore of about four pounds weight, which yielded seventeen pennyweight of gold of extraordinary ductility."[e]

In 1799, the Reed nugget was discovered in Cabarrus County, North Carolina, and some years later more lumps were found, one weighing 28

[a]The Metallic Wealth of the United States, Philadelphia, 1854, pp. 114-134.

[b]Reconnoissance of the Gold Belt of the Southern Appalachians, 16th Ann. Rept. U. S. Geol. Survey, 1895, pt. III, pp. 253-258.

[c]Herrera Dec. 1, Book IX, Chap. 5.

[d]Published by De Bry in 1591.

[e]Jefferson, Thomas, Notes on the State of Virginia, 2d Am. ed., Philadelphia, Nov. 12, 1794, p. 32.

pounds. Up to 1825 all the gold produced in North Carolina came from placer gravels, but during that year veins were opened in Montgomery County and afterwards in Mecklenburg County. Between the years 1804 and 1828, all gold of domestic production deposited at the United States mint, amounting to only $116,000, came from North Carolina; but in 1829 the mint records show a production of $2,500 from Virginia, and during the same year South Carolina sent gold worth $3,500 to the mint.

In Virginia gold was discovered at very nearly the same time in both Orange and Goochland counties. Dr. Watson states that, "the Virginia Mining Company of New York, operating between the years 1831 and 1834, the Grasty tract of land in Orange County, was the first gold mining company incorporated in Virginia. The date of the incorporation was March 10, 1832. The Orange County, Virginia, deed books show that a one-half interest in a 20-year lease on the 5-acre mining tract, dated 1829, was purchased in 1831 for $30,000 in cash."[a]

The first discovery of gold in the James River basin was probably on the Collins place in Goochland County, about 1829. The first attempt at mining was by the Fishers, who built dams across the branch and prepared to work the gravels in rockers. Before active mining had actually begun, the property was turned over to Stevens Collins, who continued to work the placers for several years, and the Fishers transferred their operations to Busby Branch, 1.5 miles southwest of Tabscott. The discovery of the gold-bearing veins at the Tellurium mine is said to have been made in 1832 by G. W. Fisher while hunting, and according to J. R. Hamilton, veins were found on the Waller property by John Moss during the same year. Discoveries on other properties in the district followed in rapid succession. When Prof. W. B. Rogers wrote his "Report of the Geological Reconnoissance of the State of Virginia, 1835," Booker's mine (the Morrow mine) was already under active development. The history of the different mines, so far as known, is given under the description of individual properties in Chapter V.

On most properties gold was found first in the branches, and as the placer gravels were frequently rich and could be worked by crude methods necessitating little or no capital, the deposits along the branches were rapidly exhausted. In most cases the mining was done by lessees, who paid a royalty of about 10 per cent. of the gold recovered. The first primitive washing was with the pan, but almost from the first rockers were used on the branch gravels. Long-toms were also used, and in a few

[a]Watson, Thomas L., Mineral Resources of Virginia, Lynchburg, 1907, p. 549.

places hydraulic mining was carried on, but most of the branches had insufficient grade to permit the use of sluice-boxes.

The veins from which the placer gold was derived were frequently discovered in working up the branches, and as the placer gravels became exhausted, a close search was made for the primary deposits. When the veins were first found, many of them were worked in a very primitive fashion, the gold being recovered by the crudest mechanical processes. The high percentage of free gold, the great depth of residual decay, and the low cost of mining these ores, helped to make such methods profitable. Small shafts or pits were sunk on the outcrops where pannings of the surface soil indicated the presence of much gold. In the decomposed rock above water level blasting was not necessary, and in some places it was possible to sink nearly 100 feet through "picking ground." The ore was usually raised by hand or sometimes with a horse-whim.

At first the ore was crushed by hand in iron mortars after a preliminary hand sorting, and the gold obtained by panning, mercury being sometimes used to amalgamate the gold. Crushing was also carried on in wooden mortars lined with iron, while the heavy pestles were attached to long sweeps operated by hand. At the Tellurium mine an arrastra driven by horse-power is said to have been employed for a short time, but was soon replaced by a stamp mill, or "pounding mill" as they were then called. According to Nitze and Wilkins this stamp mill was in operation as early as 1836, making it one of the first, if not the first, to be erected in this country. It had six wooden stamps, shod with iron, which weighed about 50 pounds each, and the ore was crushed on an iron die plate. The stamp stems were square and did not revolve as in later mills, for the cams worked in slots cut into the stems.

At a later date larger and more efficient mills were installed, a 40-stamp mill being built by Commodore Stockton at the Tellurium mine as early as 1848, while a mill with 72 stamps was in operation at the Morrow mine, Buckingham County, in 1854. Tremain steam stamps, various types of rotary pulverizers, and a number of other mills have been tried with more or less success at different mines.

As the water level was reached the rock became harder, rendering blasting necessary, the water that was encountered had to be removed by pumping, and the sulphides, which began to replace the oxidized ores found at the surface, contained less free gold. It is also probable that the total gold content of the surface ores was higher than that of the sulphide ores, because of some enrichment through concentration of a part of the

gold originally present in the eroded portions of the veins. All of these factors combined to make mining more expensive and the recovery of the gold more difficult, forcing most of the mines to cease operation after the ores above water level had been exhausted. This period in the development of many of the mines was approximately coincident with the outbreak of the Civil War, which put a stop to practically all mining operations both in Virginia and in the South generally.

Since the close of the war there have been spasmodic attempts to reopen many of the mines, and while these efforts have been accompanied by varying degrees of success and failure, they have for various reasons always ended in the same way—the final cessation of all mining. Gold can be recovered from refractory sulphide ores, but the methods of extraction are more complex and costly than the simple amalgamation processes that suffice for the oxidized ores near the surface. In the case of a producing mine, the introduction of auxiliary processes for the treatment of refractory ores necessitates an additional outlay of capital; but the metallurgical process now used had not been perfected when the exhaustion of free milling ores made the profitable handling of sulphide ores a necessity, if the mines were to remain open. It is much more costly to introduce new processes at old mines that have been long abandoned, for with the ores near the surface exhausted, prospecting is more difficult, and a larger amount of dead work must be carried out before pay ore can be developed. Most companies that have undertaken to reopen Virginia gold mines have done so with insufficient capital, and usually the men in charge of operations have lacked technical training. Mismanagement and ignorance of the common principles of mining have resulted in the erection of expensive surface plants before the mines were developed to a point that would permit the making of adequate tests of the quality and probable quantity of the ore.

The metallurgical processes which have elsewhere proved successful in recovering gold values from refractory ores, have usually included concentration of the sulphides, and separate treatment of the concentrates and tailings. The concentrates are generally smelted with other ores, or treated by chlorination or cyanidation after a preliminary roasting, while the tailings are usually subjected to some variation of the cyanide process. In 1879, a Mears chlorination plant was erected at the Phœnix mine in North Carolina, under the management of Mr. A. Thies, who improved and developed it into what was later known as the Thies process. In 1881, the Mears process is reported to have been tried at the Snead mine, but no details are given. An attempt to treat the sulphides at the Morrow mine by the Mears chlorination process, in 1893-94, is said to have failed

because of mechanical defects in the process used, though a satisfactory extraction of the gold was obtained.

According to Nitze and Wilkins a cyanide plant was in operation at the Gilmer (Young American) mine in 1893; with what success is not known. A preliminary test of the cyanide process, at the Bertha and Edith mine in 1897, is reported to have been successful, but the plant was destroyed by fire soon after completion and was not rebuilt. At the Hughes mine both concentrates and tailings were treated by the cyanide process, the sulphides being first roasted in a muffle furnace, and an extraction of over 90 per cent. is claimed.

Recently there has been renewed activity in the district, a number of the old mines have been reopened, and some new development work done, but as yet none of the mines have gone much deeper than 100 feet below the surface. As the free milling ores above water level are now practically exhausted, future mining necessarily depends on the successful treatment of sulphide ores.

PRODUCTION.

The statistics of production during the years when gold mining was most active in Virginia, are not sufficiently detailed to make possible the compilation of data giving the production of individual mines, or of the district as a whole. The few figures that are available relate to particular mines, and are given under the descriptions of the different properties in Chapter V. The annual production of gold in the James River basin has probably varied with that of the State. After the first deposit of $2,500 at the United States mint in 1829, the gold production of Virginia steadily increased until 1833, when it reached a value of $104,000. Thereafter it averaged about $56,000 yearly up to the outbreak of the Civil War, and since the war the production has ranged from a minimum of $2,024 in 1884, to a maximum of $15,000 in 1906, averaging about $6,000.

PREVIOUS GEOLOGIC WORK.

No detailed geological work dealing with this or any other portion of the gold belt in Virginia has been published previous to this report. Since the first discovery of gold, the mines in the James River basin have been examined from time to time by geologists and mining engineers, and a number of reports on individual properties have been published. Some of the early American and English geologists, who visited the district, became interested in the genesis of the ore-bodies and advanced theories to explain their mode of formation; but at that time the petrographic microscope had not been developed, and the science of geology had not reached a stage permitting detailed geological study in an area of old

metamorphic rocks. In more recent years the lack of accurate topographic maps, the depth of residual decay. and the absence of deep mines, have combined to discourage geologists from undertaking work in the district.

Several studies treating of the gold belt in the Southern Appalachians region as a whole have been published, and in these the principal mines in the James River valley receive brief mention. A number of papers, usually brief in character and dealing chiefly with the economic and engineering phases of the properties, have appeared from time to time. In the Bibliography is given a list of the titles of all the principal papers which refer in any way to the gold veins in this district. A brief review of the more important conclusions developed by the different geologists that have worked in the area is outlined below.

The first geological work, of which there is any record, was done by Prof. Wm. B. Rogers, who in 1835 published his "Report of the Geological Reconnoissance of the State of Virginia." He mapped all of the rocks in the gold belt as primary, but states that the rocks lying to the west of the belt of gneiss "assume various intermediate characters, until at length the truly crystalline structure is lost, and numerous forms of slate of very peculiar and equivocal features make their appearance. At what precise points the rocks of unequivocally primary character terminate, future researches must ascertain."[a]

In describing the veins, Rogers points out that while in the main they conform to the inclination of the enclosing strata, this correspondence is far from exact, and that in places the veins divide, and the separated portions reunite or send off other branches. From this he concludes:

"It would thus appear, that these numerous veins of quartz are not to be regarded as deposits coeval with the regularly stratified rocks among which they are found, since in that case their position and structure would exhibit a like degree of uniformity, but as matter which, subsequent to the production of the neighboring rocks, was forcibly injected between them by igneous agencies from beneath, rising in the directions of least resistance, and therefore, generally, though by no means uniformly, following the plains of stratification of the rocks through which they passed. Instead, therefore, of considering them as beds like the adjoining strata, as some writers have done, we would incline to class them among *veins of injection,* of which numerous instances occur in other parts of the globe. We are the more persuaded of the correctness of this view of their origin, from the consideration that throughout all the region in which the quartz veins are found, very peculiar modifications in the structure and composition of the surrounding rocks are invariably to be observed—modifications for which no adequate cause can be found in the other igneous rocks which occasionally occur."[b]

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[a]Rogers, Wm. B., A Reprint of the Geology of the Virginias, New York, 1884, p. 72.

[b]Ibid., pp. 75-77.

Prof. B. Silliman examined the Busby and Moss mines in 1836, and while in the district also visited the Tellurium mine. As a result of his observations he reached conclusions in regard to the nature of the veins which are at variance to those advanced by Prof. Rogers. He states that: "The auriferous or gold-bearing quartz of the gold region of Virginia (and, as far as I am informed, of the states farther south) forms, not strictly veins but rather beds or layers—in general not interfering with but conforming to the regular structure of the country."[a]

Prof. Rogers, in his "Report of the Progress of the Geological Survey of the State of Virginia for the Year 1839," describes the Triassic area lying in Prince Edward, Cumberland, and Buckingham counties under the name of "middle secondary formations,"[b] but maps the rest of the area embraced in the present report as "primary."

Prof. D. T. Ansted in 1854, after a careful study of the region, strongly opposed the theories of Rogers, both as to the genesis of the gold veins and in regard to the manner in which the Alleghanies were formed. Ansted points out the resemblance of many of the "so-called veins" to the quartzite exposed in the bluffs at New Canton and says: "It is not without importance that these hard sandstone bands pass into and alternate with quartz bands parallel to them, and that this quartz is hyaline, and has in all respects the aspect and general character of the auriferous veins of the adjacent districts."[c] He further states that:

"There were perhaps originally a multitude of beds, consisting of such materials as are still accumulating every day upon the earth. These beds were altered more or less by chemical agency, but while some still retain clear marks of their mechanical origin, others have become so far crystalline that the new arrangement of particles obliterated the old. That the syenites, greenstones, and gneissic rocks, as well as the chloritic schists, hornblendic schists, pale and blue slates, and other well-marked mechanical rocks, were once alternating aqueous deposits, there is no doubt in my mind; and I also believe that the gold as well as the iron was originally disseminated through the whole, and has been since rearranged and collected into certain portions, whether veins or bands, by a process of segregation, which has also changed siliceous sands into the condition of alternating quartz bands."[d]

[a]Silliman, B., Remarks on Some of the Gold Mines, and on Parts of the Gold Region of Virginia, Founded on Personal Observations Made in the Months of August and September, 1836, Amer. Jour. Sci. and Arts, 1837, vol. xxxii, pp. 98-130.

[b]Ibid., pp. 322-323.

[c]Ansted, D. T., The Alleghanies and the Gold District of Eastern Virginia, Scenery, Science and Art, London, 1854, Chap. 3, p. 287.

[d]Ansted, D. T., Op. cit., p. 292.

Ansted described the Waller, London and Virginia, and Morrow veins, all of which were exposed at the time of his visit, and his descriptions show that he was a remarkably careful and accurate observer.

Dr. H. Credner, during the latter part of 1865, made a detailed examination of the gold deposits of Virginia and North Carolina, and the portion of his report relating to Virginia mines, which was published in 1868-69, gives a comprehensive list of the gold-bearing properties in the James River basin. His conclusions in regard to the geology of the deposits are stated as follows:

"The slate belt is of the highest technical interest, on account of the variety and multitude of mineral deposits which it encloses. Mineralogically it is made up of soft micaceous slates, siliceous slates poor in mica, chloritic, talcose, and roofing slates. All these varieties have an immediate connection with the analogous slate formation of North Carolina, which has been named by Emmons the Taconic system. We are therefore justified in describing this Virginia slate zone as belonging to this pre-Silurian oldest fossiliferous system.

"Somewhat as the coal measures lie between carboniferous sandstones so between the layers of these slates lie parallel metalliferous intercalations, striking and dipping with the enclosing rocks and therefore not veins proper in a geological sense."[a]

In 1885, I. C. Russell made a reconnoissance of the Triassic (Newark) area lying in Prince Edward, Cumberland, and Buckingham counties, determining the presence of a fault along its eastern boundary north of Farmville, and several north and south faults in the central portion of the area.[b]

In 1892, N. H. Darton announced the discovery of fossils in the slate of the Arvonia quarries, and the identification of these fossils by Walcott placed the slates in the upper Ordovician (Cincinnatian).[c]

In 1911, Thomas L. Watson and S. L. Powell correlated the Arvonia slate belt with the Quantico slate belt in Prince William, Stafford, and Spottsylvania counties, Virginia, and described the occurrence of tuffaceous beds and metamorphosed rhyolite interbedded with the slates in each district.[d]

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[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. of Mining, 1868, vol. vi, p. 361.

[b]Russell, I. C., The Newark System, U. S. Geol. Survey, Bull. No. 85, 1892, pp. 88-89.

[c]Darton, N. H., Fossils in the "Archæan" Rocks of Central Piedmont, Virginia, Amer. Jour. Sci., 1892, vol. xliv, pp. 50-52.

[d]Watson, Thomas L., and Powell, S. L., Fossil Evidence of the Age of the Virginia Piedmont Slates, Amer. Jour. Sci., 1911, vol. xxxi, pp. 33-44.

CHAPTER II.

DESCRIPTIVE GEOLOGY AND PETROGRAPHY.

INTRODUCTION.

The results of the areal survey of the gold belt in the James River basin are shown on the geological maps, Pls. I and II, and figs. 2 and 17. Owing to the lack of sufficient exposures it is not possible to map all of the region in equal detail. Plate I is a topographic and geologic map of the entire area, on which only the principal formations are differentiated. The northwestern portion is occupied chiefly by pre-Cambrian schists, quartzites, and gneisses of sedimentary origin, and the southeastern portion, by more or less gneissic igneous rocks of the granite-diorite family. The northern end of the Farmville area of Triassic rocks crosses the southern boundary and occupies a small area between Ca Ira and Willis Mountain.

A narrow belt of Ordovician rocks extends in a southwesterly direction from a point on Long Island Creek, between Palmyra and Wilmington, nearly to Alpha in Buckingham County, a distance of about 22 miles. Its boundaries are shown on the smaller detailed maps but not on Pl. I. A large scale map of the entire slate belt will be published shortly in connection with a report on the slate deposits of Virginia, now in preparation by the State Geological Survey.

Most of the gold mines are situated in the northeastern portion of the district shown on Pl. I, and this section is given in greater detail on Pl. II. Figure 2 is a detailed geological map of the region around New Canton and Arvonia, Buckingham County, showing the distribution of the Ordovician rocks, and the relation of the New Canton copper mines to the contact between the pre-Cambrian schists and intrusive granite.

All of the rocks in the area mapped, except the Triassic sediments, have been extensively altered by regional dynamic metamorphism, the degree of alteration being most intense in the pre-Cambrian rocks. In the following detailed descriptions the rocks are divided into two classes, namely, those that are sedimentary in origin and those that are igneous in origin; and the subdivisions of the two classes are based, so far as possible, on relative age.

ROCKS SEDIMENTARY IN ORIGIN.

GENERAL CLASSIFICATION.

The rocks of sedimentary origin, described in this report, may be divided for purposes of mapping and description into three main groups—pre-Cambrian, Ordovician, and Triassic—which are separated from one another by great unconformities. These groups will be discussed in the order given, which is that of relative age.

The pre-Cambrian rocks are the oldest in the district and have been extensively altered by dynamic regional metamorphism and by the intrusion of large masses of igneous rocks. In many instances they have been so completely metamorphosed that it is difficult or impossible to discover the character of the original sediments. For the most part these rocks have a fairly uniform strike in a northeast and southwest direction, and dip toward the east at angles varying from 45 to 90 degrees.

The Ordovician sediments are next in age to the pre-Cambrian rocks, but are separated from them by a long time interval, and are much less metamorphosed. The beds of this formation have been extensively folded and faulted, and while they mostly dip at steep angles, there is not the same uniformity in this respect as in the older sediments; the dip of the Ordovician beds changes suddenly within short distances, while the pre-Cambrian rocks are nearly isoclinal in dip.

The Triassic sediments constitute the youngest formation of the area, unless the recent alluvium, deposited in the larger valleys, is taken into consideration. The Triassic rocks have not been subjected to the crustal movements which have metamorphosed the older rocks, and since they have never been deeply buried, they are only partly consolidated. The beds dip gently in various directions and have been only slightly disturbed by minor faulting.

PRE-CAMBRIAN.

General Statement.

In the absence of direct fossil evidence, the correlation of the rocks which have been mapped as pre-Cambrian must rest entirely on lithologic and structural grounds. It is known that the Proterozoic era in North America was brought to a close by great crustal movements, and wherever the rocks belonging to this period have been observed in the Piedmont region, they show the effects of intense dynamic metamorphism. The chief evidence of the pre-Cambrian age of the older rocks, in the area under consideration, is furnished by their relatively high degree of crystallinity

and extremely schistose structure as compared with the rocks a short distance to the west, which are believed to be Cambrian in age. (See Geological Map of Virginia.[a])

The great age of these rocks is also evidenced by the long period of time intervening between their formation and the deposition of the Arvonia slates, upper Ordovician (Cincinnatian) in age, which are the oldest rocks in the area known to be fossil-bearing. After the pre-Cambrian sediments were laid down, they underwent the profound changes which resulted in their metamorphism; they were intruded by great masses of igneous rocks; and finally, sufficient time elapsed for erosion to remove a large amount of overlying material, and expose the intrusive granite and other rocks of the anamorphic zone; and all of this happened prior to the deposition of the Ordovician sediments.

The subdivisions of the pre-Cambrian series in this district must be based, in the absence of fossils, entirely on lithologic grounds. It is not even possible to state definitely which beds were laid down first or which were laid down last. The rocks have all been extensively altered by regional metamorphism and are entirely crystalline, so that it is frequently difficult to determine their original character; and in some instances, especially in the vicinity of later intrusives, it is impossible to distinguish between those that are igneous and those that are sedimentary in origin. The principal rock types are quartzites, schists, and gneisses, varying in texture and mineral composition; and rocks occur that are intermediate between the more important varieties. In fact nearly all gradations exist between the different extremes in mineral composition.

Quartzite.

GENERAL CHARACTER AND DISTRIBUTION.

Quartzites are fine-grained, siliceous rocks, originally deposited as beds of sand and later firmly cemented through metamorphic agencies. Some of the pre-Cambrian quartzites in this area are very pure, consisting almost exclusively of quartz, but usually there is more or less mica and chlorite present in small flakes, and with increase of these minerals the rocks grade into mica schists. In places the quartzites are highly ferruginous, containing considerable percentages of hematite and magnetite, and at several localities the iron content is so high that the beds have been prospected for

[a]Watson, Thomas L., Geological Map of Virginia, Virginia Geological Survey, 1911.

iron ore. The quartzites also contain variable but usually unimportant amounts of feldspar, small inclusions of zircon, ilmenite, and rutile needles; and near igneous contacts, such minerals as garnet, hornblende, sillimanite, and cyanite are occasionally present in the impure varieties.

Since they are strongly resistant to erosion, the quartzites commonly outcrop along the ridges, and in places where the larger streams cut through such ridges the valleys are narrower, being frequently enclosed by cliff-like bluffs, while rapids are present in the channels. The residual soils resulting from the disintegration of the quartzites are sandy and infertile.

Most of the quartzite beds are less than 20 feet in thickness but some of them measure over 200 feet. They are frequently lenticular in shape, pinching out along the strike and dip, though some of the more persistent beds can be traced for a distance of several miles. The quartzites are the most widely distributed of all the rocks in the pre-Cambrian series of altered sedimentaries, yet, owing to the high inclination of these beds they do not form extensive areal formations.

The beds of quartzite are commonly mistaken for quartz veins and much money has been wasted in sinking pits to prospect them for gold.

DETAILS OF OCCURRENCES.

Bremo Bluff.—The most prominent exposures of quartzite occur on either side of James River just above the railroad station at Bremo Bluff. Here within a distance of half a mile there are a number of beds, ranging up to 200 feet and over in thickness, which are interbedded with fine-grained schists, the strike of the formations being about N. 20° E., and the dip 80° to 90° east. The largest beds of quartzite outcrop near the Bremo bridge over James River, and in passing westward they become successively thinner and more impure until they entirely disappear.

Because of their great resistance to erosion the larger beds of quartzite form a ridge, having an elevation of about 150 feet above the floor of the valley; and where this ridge is cut through by the river, it terminates in abrupt cliffs (see Pl. III, figs. 2 and 3), and the valley is much narrower than it is a short distance above and below (see map, fig. 2). The ledges of quartzite outcrop in the bed of the river, causing the rapids shown in Pl. III, figs. 1 and 2. The piers supporting Bremo bridge are built on one of these outcrops.

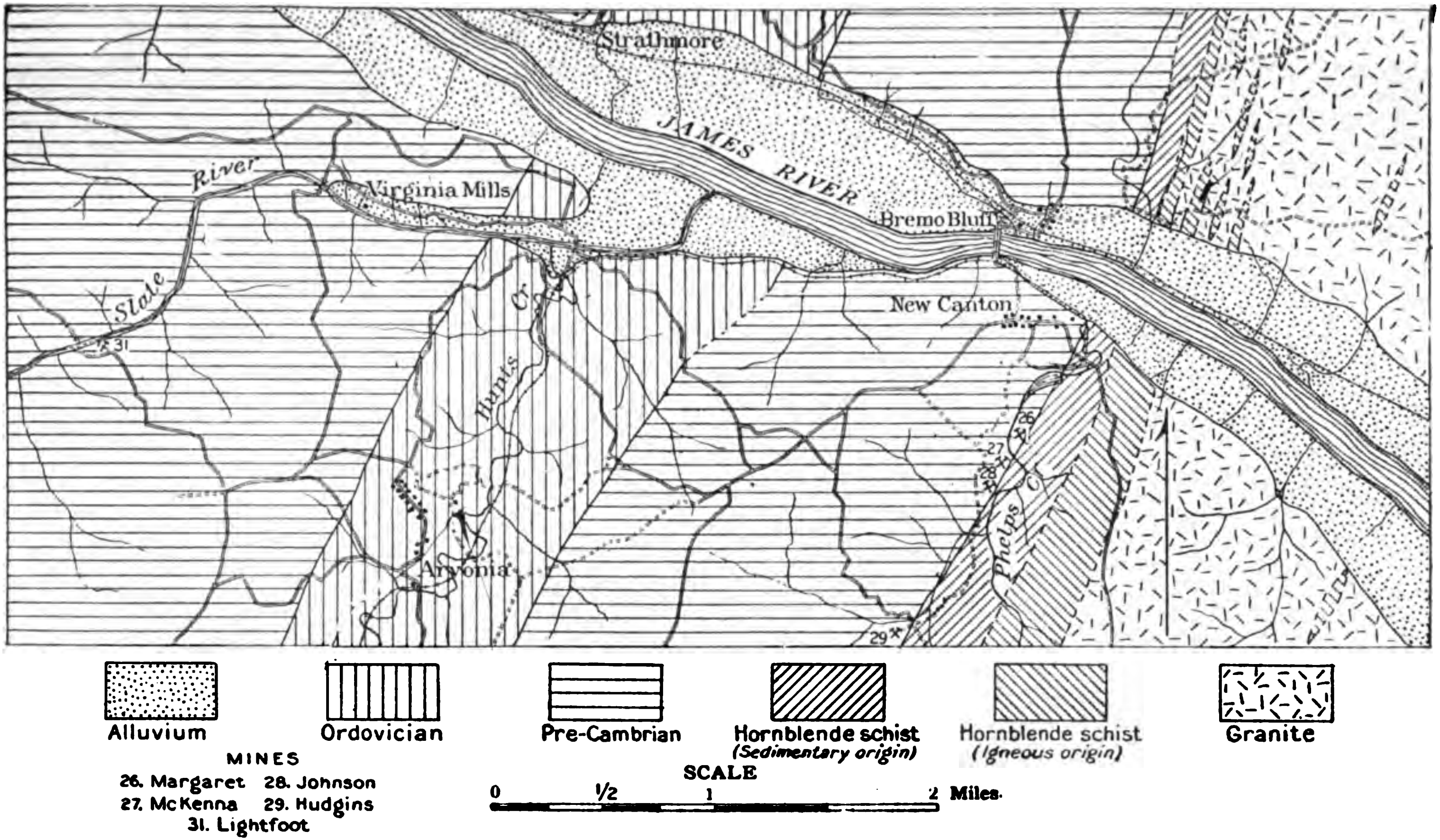

Fig. 2.—Geologic map of Arvonia–New Canton Area.

The quartzite is a fine-grained, close-textured rock, light gray in color when fresh, turning to light brown upon weathering, and where purest is nearly massive. The crustal movements, which have intensely metamorphosed the softer rocks with which they are interbedded, have scarcely affected the quartzites. Close inspection, however, shows a slight schistosity parallel to the bedding, and this becomes more conspicuous where the rocks are less pure. Fine flakes of sericite, chlorite, and biotite, and more rarely a little magnetite, pyrite, and garnet are the principal mineral impurities that may be detected megascopically.

In places the quartzites contain numerous small angular cavities arranged in bands or zones parallel to the bedding, and some of these are filled with calcite. The shape and distribution of these holes suggests that they may be due to fossils, possibly brachiopods, but if so they are so badly distorted as to make identification impossible. Quartz veinlets, averaging less than an inch in thickness, occasionally cut the quartzite, and some of the veinlets contain calcite.

Examined in thin sections under the microscope, the quartzite (Spec. 452)[a] consists chiefly of small grains of quartz, nearly uniform in size, which fit closely together as in a mosaic. Dust-like inclusions are plentiful, especially near the border portions of the grains. The quartzite has evidently undergone considerable recrystallization, with possibly some enlargement of the original grains by the addition of quartz in parallel orientation; and the border inclusions probably represent iron oxide and other interstitial material which has become incorporated in the enlarged grains. Garnet occurs in small, irregular grains which are much fractured and partly altered to chlorite. Numerous small flakes of sericite are present, probably derived chiefly from argillaceous material, and there is also a little plagioclase and orthoclase feldspar, some of which shows partial alteration to sericite. Chlorite occurs in small, dark green flakes, and other minor accessories are biotite, light brown to green in color, a few small grains of magnetite and pyrite, and minute, colorless inclusions of zircon. The quartz shows very little optical distortion, possibly because of the extensive recrystallization.

Tellurium mine.—The so-called "Big Sandstone" vein, at the Tellurium mine, is a bed of quartzite cut by gold-bearing veinlets and slightly mineralized by the vein-forming solutions. This bed of quartzite varies up to 6 feet or more in thickness and can be traced for a distance of 3

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[a]The numbers placed in parenthesis refer to field specimens and microscopic thin-sections, which are on file at the office of the Virginia Geological Survey.

Fig. 1.—Looking up James River from Bremo bridge. Rapids due to quartzite beds.

Fig. 2.—Quartzite cliffs near north end of bridge. Looking northeast.

Fig. 3.—Nearer view of quartzite cliffs on north side of James River. Bremo Bluff.

PRE-CAMBRIAN QUARTZITE AT BREMO BLUFF.

miles or more along its line of strike. The rock is white to light gray in color, when fresh, with a slightly pinkish tinge on weathering. It is quite free from impurities other than sericite, which is the only accessory mineral that can be distinguished with the naked eye. For a detailed microscopic description of this rock see pages 161-163.

London and Virginia mine.—At the London and Virginia mine there is a similar bed of quartzite, which in places is heavily impregnated with pyrite and more or less gold. This bed of quartzite ranges up to 20 feet or more in thickness, and the series of outcrops and prospect pits located along its line of strike indicate that it is practically continuous for a distance of 10 or 12 miles. Specimens of this quartzite from the London and Virginia and the Bondurant mines are described on pages 189 and 193-194, respectively.

Ferruginous Quartzite.

GENERAL CHARACTER AND DISTRIBUTION.

The ferruginous quartzites consist essentially of quartz, hematite, and magnetite. These three principal constituents vary greatly in their relative proportions, but quartz is usually dominant, though locally the iron oxides may constitute 80 or 90 per cent. of the mass. Some of the iron-bearing quartzites contain a little sericite and biotite, and with the increase of these minerals the rocks pass into ferruginous schists.

The ferruginous quartzites are of more frequent occurrence than the pure quartzites, and are found interbedded with the other sedimentary rocks in almost every portion of the pre-Cambrian area.

DETAILS OF OCCURRENCES.

Webb tract.—On the Webb tract, about three-quarters of a mile southwest of Lantana, a bed of ferruginous quartzite has been prospected for iron, and is exposed in several surface pits that have been sunk. The bed is over 6 feet in thickness, has an approximate strike of N. 45° E., and dips southeast at an angle of about 25°. It is interbedded with arkosic-gneisses, quartz-sericite schists, and other beds of quartzite.

The rock is fine-grained, even-granular, and, when fresh, is brownish-gray in color, turning to dark brown or black on weathering. It is composed essentially of quartz, specular hematite, and magnetite, but a little sericite may sometimes be recognized with the aid of a lens. It is slightly gneissic in structure, because of some recrystallization, accompanied by a partial segregation of the quartz and iron ores into narrow bands parallel

to the bedding and schistosity. The magnetite in these segregated bands or layers, which are usually 3 mm. or less in thickness, is somewhat coarser than that in the rest of the rock.

The quartzite is cut by numerous irregular quartz stringers, ranging up to 3 or 4 inches in width, and, for the most part, conforming to the strike of the enclosing rock. These quartz veinlets in places contain plates of micaceous hematite. Near the veinlets the quartzite seems to have been leached of some of its iron content.

Examined in thin section (Spec. 95) under the microscope, the quartzite shows a slightly schistose structure due to the partial arrangement of the iron ores in parallel lines. The quartz grains average about 0.25 mm. in diameter, and fit closely together, interlocking almost perfectly, but there is no evidence of granulation or optical distortion. The quartz individuals contain numerous small, dark red crystals of martite, the isometric form of hematite, which usually occur in well-formed octahedrons and are probably secondary (pseudomorphous) after magnetite. The larger masses of iron oxide are present between the quartz grains, and are frequently arranged in irregular, broken lines. Occasional hexagonal outlines show that a large proportion of the oxide is hematite, but much magnetite is also present. The fact that the quartz individuals in immediate contact with these larger masses of iron ore are practically free from the small inclusions, indicates that both the quartz and the iron ores have undergone recrystallization, accompanied by a partial segregation of the latter into larger masses. In places the iron ores are partly altered to limonite, and the boundaries between the quartz grains frequently show limonite staining. Considerable garnet (probably chiefly spessartite) is present, usually occurring as an interstitial filling between the quartz grains, and frequently along the contact between quartz and the iron ores. It is evidently secondary in origin, and, in some instances, appears to have partly replaced the quartz. The garnets are usually full of small dust-like inclusions, and more or less stained with limonite. Small, light green to colorless inclusions of zircon are common but not abundant.

The Ayre tract.—On the Ayre tract, 3.5 miles east of Dillwyn, a large bed of ferruginous quartzite has been extensively prospected for iron ore by several shafts and open cuts. One of the shafts is 40 or 50 feet deep, the others being somewhat less.

The quartzite outcrops boldly, in places standing 6 to 8 feet above the surrounding surface, and along most of its course follows the crest of a

ridge. The outcrops vary in width up to 200 feet or more, and the bed can be traced for over half a mile in a direction about N. 45° E.

The rock is essentially the same, both megascopically and microscopically, as that described above. Some of it is slightly coarser grained, and octahedral crystals of magnetite 0.5 mm. in diameter can be distinguished in hand specimens. Sericite is sparingly present.

Spessartite is occasionally present in the quartzite, occurring in irregular and more or less angular masses that range up to a foot or more in diameter. These masses are reddish-brown in color, with a waxy luster, and the weathered surface shows irregular, hackly cracks. Under the microscope (Spec. 420) the garnet is even-textured with few fractures and is seen to be full of extremely small inclusions. A few scattered grains of hematite are present, and with them there is often associated a little chlorite in fine, green shreds. The garnet is more or less stained by limonite.

The quartzite is cut by numerous stringers of vein quartz, frequently containing prisms of black tourmaline; and one specimen was found in which radiating clusters of tourmaline had penetrated the quartzite to a depth of about 0.5 cm. A large amount of tourmaline is present on the surface near the outcrops. A number of other occurrences of iron-bearing quartzite are reported southwest of this locality, in the vicinity of Willis Mountain.

The Scotia mine.—On the Scotia mining property, a bed of ferruginous quartzite, known as the Hodges vein, has been prospected for gold. The quartzite is cut by a number of small, gold-bearing veinlets, and has been slightly mineralized by the vein-forming solutions; otherwise it is identical with the other ferruginous quartzites of the district. The development work that has been carried out is sufficient to expose the marked lenticular shape of the deposit (see fig. 16, p. 171). A megascopic and microscopic description of the rock is given on pages 171-172.

Other localities.—Ferruginous quartzites occur at numerous other localities within the area mapped and thin sections from a number of them have been studied under the microscope, but as all of these are essentially the same, they will not be described in detail. At Cassell's mine 2 miles northeast of Caledonia a bed of iron-bearing quartzite 8 feet or more in thickness has been prospected by a surface pit. The rock exposed seems to have undergone greater recrystallization than most of the similar deposits in the area. It is described in detail on pages 174-175.

Ferruginous quartzite outcrops along the road three-quarters of a mile south of Stage Junction, where the bed has a strike of about N. 20° E.

Another occurrence is located on the road from Stage Junction to Pryors Crossroads, at a point three-quarters of a mile northeast of Big Byrd Creek. Outcrops also occur near the road between Palmyra and Wilmington, at Fork Union, and at several points in the vicinity of the Hughes mine. At the last-named locality some of the specimens have the appearance of hematite breccias recemented with magnetite and hematite.

Garnetiferous Quartzites.

GENERAL CHARACTER AND DISTRIBUTION.

Garnetiferous quartzites occur at several places in the district and are believed to be due to the metamorphic action of igneous intrusive rocks on impure quartzites. Chemical tests prove that the garnets are the iron-aluminum variety known as almandite. Sillimanite and sometimes a little cyanite are also present in association with the garnet. These rocks usually contain more or less hematite, magnetite, and sericite, and pass by gradation into the schists with which they are interbedded.

This type of rock has a limited distribution and was found only in the vicinity of contacts between the pre-Cambrian sediments and the intrusive granite.

DETAILS OF OCCURRENCES.

Lantana.—A bed of garnetiferous quartzite outcrops at Lantana, and for a mile southwest of the postoffice the road to Columbia follows approximately along the strike of this bed. It was traced in a northeast and southwest direction for a total distance of about 4 miles. The bed is probably not more than 10 or 15 feet thick and is usually much thinner.

The rock is banded in light and dark layers which range up to 2 or 3 inches in thickness. These layers are parallel to the bedding, the dark ones being composed largely of garnets while the light ones are chiefly of quartz. Radiating needles of sillimanite are common in places, and a little cyanite was identified. The garnets are dark red to brown in color, ranging up to about 0.5 cm. in diameter, but show very poor crystal form. Under the microscope (Spec. 96) they are seen to be full of small inclusions consisting of quartz and oxide of iron. These inclusions are elongated and arranged in lines approximately parallel to the bedding. The garnets are much fractured, and are stained by limonite which also coats many of the quartz grains. The quartz shows evidence of considerable optical distortion and of extensive recrystallization. Near the garnets the grains of quartz are sometimes arranged in bands that pass

around these crystals. There are a few flakes of sericite present, and the only other constituent noted was a soft white mineral that occurred as a coating and filled small cavities. It is probably some form of amorphous silica.

Weathered specimens of this rock often exhibit a hard surface crust having a rich reddish-brown color due to the presence of hematite, the iron of which has been leached from the partly decomposed minerals within, and reprecipitated near the surface.

The quartzite is interbedded with and grades into a fine-grained quartz-sericite schist.

Stage Junction.—A bed of garnetiferous quartzite outcrops in the road about half a mile northeast of Stage Junction. It is more schistose than the rock near Lantana, but is otherwise the same.

Hornblende-Bearing Quartzites.

Quartzites containing a few crystals of dark green hornblende occur at several localities close to the contact with the large area of intrusive granite, but they are of very limited distribution and therefore unimportant. The rocks placed in this classification are intermediate between the normal quartzites and the hornblende schists.

On the Columbia-Lantana road, three-quarters of a mile west of the bridge over Big Byrd Creek, there is an outcrop of hornblende-bearing quartzite. The rock contains blade-like crystals of hornblende, dark green to black in color, and ranging up to 3 mm. in diameter, which are embedded in an even-granular ground-mass of quartz with a few scattered crystals of garnet and sillimanite. A similar rock was found at the Margaret mine near New Canton (see p. 250).

A fine-grained quartzite containing scattered prismatic crystals of dark green hornblende is exposed on the east side of Randolph Creek, where it is crossed by the road running from Lawford to Gold Hill. A similar rock was noted near Hatcher Creek about 3 miles west of Hatcher.

Quartz-Sericite Schist.

GENERAL CHARACTER AND DISTRIBUTION.

Schists composed essentially of quartz and sericite in varying proportions are of common occurrence in all portions of the pre-Cambrian series of sedimentary rocks, and constitute one of the most important rock types of the area. In texture these schists range from fine to medium coarse-

grained, and in composition from sericite-bearing quartzites to rocks in which the mica is dominant. The finer grained varieties, containing much sericite, were described by the early geologists under the name of talcose schists. The coarser varieties, in which quartz is dominant, are very resistant to erosion and therefore frequently form the ridges and other higher elevations, outcropping with considerable prominence. The quartz-sericite schists pass by gradation into the sericite-bearing gneisses, cyanite schists, and the ferruginous as well as the pure quartzites. Nearly all the schists found in this region contain more or less sericite, and there are numerous rocks intermediate in mineral composition between the quartz-sericite schists and most of the principal varieties.

GENESIS.

The positive evidence of bedding and the gradation of the quartz-sericite schists into rocks, such as the quartzites, which are necessarily sedimentary in origin, leave no doubt as to the manner in which the schists were originally formed. The beds were probably laid down in shallow waters near the shore, partly in the form of quartz-feldspar sands and argillaceous sands, and partly in the form of finer sediments, possibly white clays. The present character of the rocks is due to their alteration under dynamic conditions in the zone of anamorphism, and certainly in some cases the change has been aided by the intrusion of the large granite magmas.

DETAILS OF OCCURRENCES.

Big Byrd Creek.—On the east bank of Big Byrd Creek, three-quarters of a mile south of Bowles' bridge, and 1¼ miles east of Stage Junction, there is an exposure of quartz-sericite schist in which the ratio of quartz to sericite is so great that it is almost a quartzite. The rock (Spec. 33) is fine-grained and white to light yellow in color when not stained pink and red by oxides of iron. It is highly laminated parallel to the schistosity, showing well-marked layers which are slightly folded and crumpled. The minerals distinguishable under the microscope are quartz, sericite, a little feldspar, and occasional inclusions of zircon. The quartz grains fit closely together and show little optical distortion. The feldspars are chiefly acid plagioclase and in places they show partial alteration to sericite. Most of the mica flakes are perfectly oriented parallel to the schistosity.

Lantana.—For a distance of 500 or 600 yards southeast of Lantana the road passes across a belt of quartz-sericite schist, and this belt may be traced

for 4 or 5 miles along its line of strike in a northeast and southwest direction, but in places it contains interbedded lenses of quartzite and other rocks. The schist (Spec. 42) is white to light gray in color, where not stained with iron, and usually fine-grained. Quartz is dominant over sericite, the flakes of which are all oriented parallel to the schistosity, so that when the rock is examined on surfaces at right angles to the cleavage it has the appearance of a quartzite rather than a schist. It is slightly banded, due to variation in the relative proportion of the quartz and sericite, and the layers show minor crumpling and folding.

A specimen (100) obtained from an outcrop 2¼ miles northeast of Lantana, upon examination in thin section under the microscope, shows a little orthoclase and acid plagioclase feldspar, and occasional fluid inclusions and rutile needles. The feldspars show partial alteration to sericite and are much kaolinized.

About a mile northeast of Lantana occurs a rock which is intermediate in composition between the quartz-sericite schists and the ferruginous quartzites. It is a fine-grained schist, bluish-gray in color, in which few of the minerals can be distinguished by the naked eye. In thin section (Spec. 89) under the microscope it is seen to consist essentially of quartz, hematite, and sericite, with a few scattered crystals of nearly colorless amphibole and possibly a little cyanite. The quartz grains are irregular in shape, fit closely together, and show some optical distortion. The hematite is chiefly of the micaceous variety.

New Canton-Dillwyn road.—There are numerous outcrops of quartz-sericite schist along the ridge road leading from New Canton to Dillwyn. This rock is slightly coarser grained than the schists previously described, and the schistosity usually has a crinkled or corrugated appearance. It is light greenish-gray to white in color, where not stained various shades of pink by iron oxides, and is composed essentially of quartz and white mica, with a small amount of light green chlorite, and occasional specks of specular hematite. It is very resistant to erosion and therefore outcrops prominently and forms the watershed between the streams flowing into Hunts Creek and Slate River, and those flowing into Phelps Creek and Willis River. Locally the schist is called *mountain rock,* because of its occurrence along the summits of the higher ridges.

A similar rock outcrops on Tower Hill, 2½ miles south of Alpha and 3½ miles east-northeast of Dillwyn, and also on the slopes of Willis Mountain.

London and Virginia mine.—A fine-grained quartz-sericite schist is exposed at the London and Virginia mine and at the other mines that

have been opened along the strike of the same vein. In this rock the percentage of sericite is high and is possibly dominant over the quartz. The schist, as well as the quartzite with which it is interbedded, has in places been heavily impregnated with pyrite. A detailed megascopic and microscopic description of the rock is given on page 186. A similar rock occurs in the mines near New Canton, and is especially prominent at the Hudgins mine (see p. 256).

Bondurant mine.—A quartz-sericite schist, which was found on the dump at the Bondurant mine, contains small lenticular eyes of light-blue opalescent quartz. This variety of the schist is similar to the hand specimen (211) obtained from the Scotia mine and described on page 170.

Other localities.—Quartz-sericite schist is present along the road 3 miles northwest of Ca Ira and parallels the contact with the granitic rocks on the east for a distance of several miles in a northeast and southwest direction. It occurs in the road 2 miles south of Kent's Store, and also a quarter of a mile northeast of Byrd Creek on the road between Stage Junction and Pryors Crossroads; it outcrops on Byrd Creek, 1¼ miles north of Grays Mill, and in the road three-quarters of a mile south of Carysbrook; and it was noted along the road 1½ miles south of Gravel Hill. There are numerous other occurrences in the area, but these are sufficient to show the wide distribution of this rock type.

Cyanite Schists.

GENERAL CHARACTER AND DISTRIBUTION.

The cyanite schists are composed chiefly of quartz, cyanite, and sericite or muscovite, and the relative proportions of these constituents vary within wide limits. There are all gradation from a rock composed almost entirely of cyanite, to one composed chiefly of coarse-grained quartz with only scattered prisms of cyanite; and these schists pass by gradation into quartz-sericite schists in which cyanite is sparingly present or entirely absent. Cyanite is also present in some of the gneisses that have been intensely metamorphosed (see pp. 133 and 136-138).

The distribution of these schists is very limited and only two occurrences are known within the limits of the area mapped—one at Willis Mountain, and the other on the Trent farm, 3½ miles southeast of Gravel Hill and 3 miles southwest of Hatcher. Similar schists have been described from the northwest corner of Charlotte County, about 25 miles southwest of Willis Mountain, and it is interesting to note that in each instance rutile is a prominent minor constituent.[a]

[a]Watson, Thomas L., and Watkins, J. H., Association of Rutile and Cyanite from a New Locality, Amer. Jour. Sci., 1911, vol. xxxii, pp. 195-201.

While cyanite is softer than most rock-forming minerals, it is almost unalterable, and therefore the cyanite schists are extremely resistant to the agents of decomposition, and outcrop boldly at each of the localities in this section.

GENESIS.

The structural relations of the cyanite schists, wherever observed, are indicative of a sedimentary origin, and, moreover, cyanite is not known to occur as a pyrogenetic mineral. The chemical composition of these schists, consisting chiefly of alumina and silica, suggests that they must have been derived from kaolin or very argillaceous sediments, and this view is supported by the unusually high titanium content. Van Hise has called attention to the concentration of titanium in shales and other fine-grained sedimentary rocks.[a] The metamorphic minerals composing these schists were produced in the anamorphic zone under conditions of dynamic regional metamorphism, but the location of both occurrences, not far from large areas of intrusive granites, suggests that contact action may have been an influential factor in bringing about the alterations. Evidence in favor of the latter hypothesis is furnished by the variation in the character of the schist in the vicinity of a peculiar diorite dike, which occurs on the southern slope of Willis Mountain, and by the great abundance of tourmaline, chiefly in association with vein quartz, found near the base of the mountain. The absence of cyanite, sillimanite, and similar minerals from most of the contact rocks is probably due to the presence of iron, magnesium, and the alkalies, which have resulted in the formation of amphibole and mica rather than the pure aluminum silicates.

DETAILS OF OCCURRENCES.

Willis Mountain.—The topographical features of Willis Mountain are described on pages 89-91, the formation of the narrow ridge being attributed to the structural and lithologic character of the bed of cyanite schist which outcrops along the summit. This rock was described under the name of "kyanitic gneiss" by Rogers, who states that it "differs from all in its vicinity, and appears to have been elevated from below through the surrounding slates;"[b] but the present writer saw nothing to indicate that faulting has been a factor in the formation of the mountain. The rocks

[a]Van Hise, C. R., A Treatise on Metamorphism, Mono. xlvii, U. S. Geol. Survey, 1904, pp. 974-975.

[b]Rogers, W. B., Geology of the Virginias, 1884, pp. 314-315. (See also pp. 71-72 and 290-291.)

that constitute Willis Mountain offer greater resistance to erosion than any of the other rock types found in this region, and the gradual erosion of the softer rocks has left this ridge standing as a monadnock high above the level of the Piedmont peneplain. The rugged and cliff-like nature of the outcrops near the summit of the mountain is shown in Pl. IV, fig. 1.

The cyanite schist of Willis Mountain varies in texture according to the relative proportions of the two principal constituents—quartz and cyanite—and passes by gradation into the quartz-sericite schists with which it is interbedded. In places the rock is composed dominantly of cyanite, in large-bladed crystals, white to light gray or bluish-gray in color, and there are only minor amounts of quartz and sericite, the latter being sometimes practically absent; but elsewhere medium-grained saccharoidal quartz is predominant, with small prisms of cyanite scattered through the ground-mass. Rutile, occurring in small bright red grains disseminated indifferently through the other minerals, is the only remaining constituent which is ordinarily present, though tourmaline may occasionally be seen.

The cyanite crystals range up to 7 or 8 cm. in length, and on the weathered surface stand out in high relief. Under the microscope (Spec. 386) the mineral is colorless, frequently shows a slightly radiating texture, the cleavage is well developed, and occasionally there is a little alteration to sericite along the cleavage planes. Numerous irregular grains of rutile are present as inclusions, being usually arranged with their longer diameters parallel to the cleavage planes of the cyanite. The dominantly cyanitic variety of the schist has a noticeably high specific gravity.

On weathered surfaces the rock is often deep red to purple in color and much harder than at a distance of a few inches within the interior. This is due to the solution of the small amount of iron originally present, and its transportation by capillary attraction to the surface, where it is re-deposited by evaporation, partly in the form of limonite and partly as hematite.

On the southern slope of Willis Mountain, in the immediate vicinity of a diorite dike, the cyanite schist has been extensively altered with the production of new minerals, such as light brown biotite, nearly colorless chlorite, plagioclase feldspar, and calcite. The rock is heavily impregnated with pyrite, and about 40 years ago two shafts were sunk in this material in prospecting for copper. The rock is described in greater detail on page 114.

Trent farm.—On the Trent farm, 3½ miles southeast of Gravel Hill and 3 miles southwest of Hatcher, there is a dike-like ledge of cyanite

Fig. 1.—Cyanite schists outcropping near summit of Willis Mountain.

Fig. 2.—Cyanite schists outcropping on the Trent farm.

OUTCROPS OF CYANITE SCHIST.

schist which outcrops for several hundred yards along the crest of a low ridge. It is 3 to 12 feet wide and in places stands 8 or 10 feet high, resembling a stone wall (see Pl. IV, fig. 2), and, indeed, it has been used as part of a fence to restrain cattle. This bed of schist has a strike of N. 10° E. and dips 30° to 40° E.

The rock is a heavy, compact schist, pink in color, and composed essentially of cyanite, quartz, and sericite. The cyanite occurs in flat-bladed prisms ranging up to 2 or 3 cm. in length, the quartz is medium-grained with a saccharoidal texture, and the sericite is present in small, glistening flakes. Examined under the microscope (Spec. 393), the cyanite is colorless, occasionally shows polysynthetic twinning, and in places is partly altered to sericite. Rutile is sparingly present in small grains, and a little titanite was noted in some of the quartz individuals. Fairly well formed zircons are also present as small inclusions in the quartz, and there is a little limonite, partly occurring as a stain on the other minerals.

The cyanite schist is interbedded with a medium-grained quartz-sericite schist (Spec. 394), white when fresh, and light brown to pink when stained with iron. Examined under the microscope, cyanite is seen to be present as a subordinate constituent and frequently shows multiple twinning with indefinite boundaries between the twins. Limonite is present as a stain along the contacts between the individual minerals, and also occurs in minute spherulites. A few inclusions of zircon are present in the quartz.

Knotted Schists.

GENERAL CHARACTER AND DISTRIBUTION.

Knotted schist is the name given to a series of fine-grained rocks, composed essentially of quartz, sericite, chlorite, and biotite, in which there are numerous pseudophenocrysts of garnet, biotite, carbonate, or pyrite—the latter minerals being of later formation than the schistosity of the rock. These large crystals were formed under mass static conditions, after the movements which produced the cleavage of the rock had ceased, for they show absolutely no parallelism in their orientation. They began to crystallize about favorable nuclei, and as they grew, the folia of the schist were gradually pushed aside, so that lenticular eyes or knots were formed, about which the enclosing folia are smoothly curved. The development of these minerals furnishes a very pretty illustration of the force exerted by growing crystals.

When the knotted schists are examined in thin sections under the microscope, it is seen that the minerals of the ground-mass have made room for the crystals of later growth partly by bending and partly by recrystallization. The micaceous minerals of the ground-mass are imperfectly arranged in thin layers or bands, which alternate with layers composed of quartz grains elongated parallel to the schistosity. Opposite the pseudophenocrysts, the layers of mica are pushed close together (see Pl. V, fig. 1, and fig. 21, p. 227), while the quartz which has been removed from these points has recrystallized in the ends of the lenticular eyes. In other words, the quartz has acted very much as ice does under pressure—it has gone into solution where the pressure was greatest and recrystallized where the pressure was least; and this transfer of material was undoubtedly brought about by the small amount of interstitual water present in the rock. In recrystallizing, the quartz grains have been partly arranged with their greater diameters oriented in directions pointing toward and away from the pseudophenocrysts, so that in thin sections cut parallel to the schistosity the quartz grains surrounding one of these larger crystals have a radiating texture (see Pl. V, fig. 2, and fig. 22, p. 228).

The particular kind of mineral present in the lenticular knots seems to vary with their distance from the contact of the sedimentaries with the later granite intrusives; near the contact garnets are present, farther away biotite crystals take the place of the garnets, and at greater distances impure crystals of siderite form the chief constituent of the lenses. These facts will be considered at greater length in the detailed descriptions of individual occurrences and in the discussion of metamorphism (see p. 107).

The knotted schists always have a fine-grained ground-mass, and in places they closely approach slates, both in fineness of texture and in perfection of cleavage—in fact they have commonly been described as slates; but, since the principal mineral constituents can usually be distinguished with a pocket lens, it has been thought best in this report to classify them all as schists.

The knotted schists constitute one of the most important members of the pre-Cambrian series of sedimentaries, and have a maximum thickness of perhaps 5,000 feet or more. They are interbedded with the other schists and quartzites, and are found in three principal belts. These belts are described below in detail.

DETAILS OF OCCURRENCES.

New Canton.—The best exposures of the knotted schists are furnished by the bluffs along the south side of James River in the vicinity of New

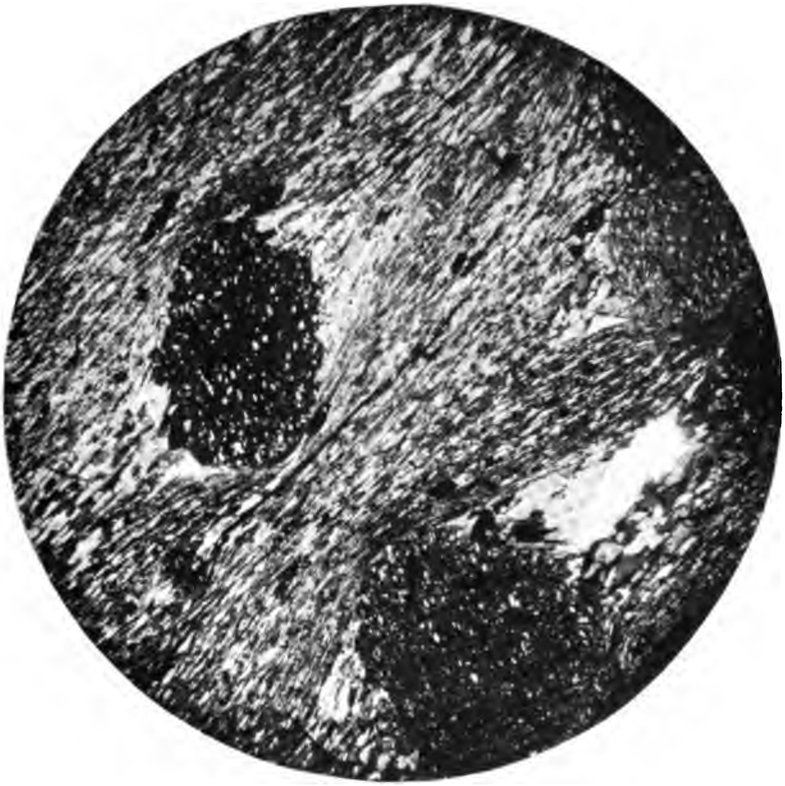

Fig. 1.—Photomicrograph of biotite-bearing knotted schist; thin section cut perpendicular to the schistosity. With analyzer. Magnified 27 diameters. See page 32. Specimen No. 307.

Fig. 2.—Photomicrograph of garnetiferous knotted schist; thin section cut parallel to the schistosity. With analyzer. Magnified 27 diameters. See page 168. Specimen No. 178. Tellurium Mine.

PHOTOMICROGRAPHS OF KNOTTED SCHISTS.

Canton. Here the schists are interbedded with the quartzites described on pages 16-18, and the whole formation is upturned so that the beds are now dipping almost vertical. The average strike is about N. 20° E.

On the east, these schists extend almost to the railroad bridge over Phelps Creek, where they pass into the belt of hornblende schists that occurs along the contact between the granite and the older sedimentaries. This contact and the rocks in its vicinity are described in detail under contact metamorphism on pages 107-112. Near the bridge over James River the schists are interbedded with several beds of quartzite, and west of these the schists continue as far as the belt of Ordovician sedimentaries. The total breadth of the formation is nearly 1½ miles and the whole series is apparently conformable, though it is possible that there has been some close folding resulting in repetition of beds.

The river bluffs and the railroad cuts along the line of the Buckingham Branch of the Chesapeake and Ohio Railway, furnish an almost continuous exposure across the entire formation. The schists on the west side will be described first, as these are farthest from the contact with the granite, and then the variations that are encountered in passing eastward across the formation will be considered in detail.

The rock exposed 1,200 yards west of Bremo bridge and about 2,000 yards west of the contact with the granite, is a fine-grained knotted schist (Spec. 445), dark bluish-gray in color, containing lenticular eyes of impure siderite ranging up to 4 or 5 mm. in diameter. In fineness of texture this rock closely resembles the slates of the Ordovician formation, and but for the fact that it passes by gradation into the true schists, it would probably be preferable to classify it as slate. The rock shows a closely spaced fracture cleavage, which intersects the flow cleavage and bedding at an angle of nearly 90°. Considerable pyrrhotite is present, sometimes forming small lenses, and there are occasional narrow veinlets of calcite. The ground-mass is composed essentially of the micas—chiefly sericite, quartz, and a little carbonate and iron oxide.

A specimen (444) obtained from an outcrop about 1,000 yards west of the bridge is typical of most of the schist found at a distance from the contact. The rock is fine-grained, but is slightly coarser in texture than the specimen last described, and the color is a much lighter shade of gray. It contains numerous small knots due to the presence of lenticular eyes of impure siderite, averaging about 1 mm. in diameter, and a little pyrite and pyrrhotite can be distinguished with the aid of a lens. The rock is cut by occasional veinlets of calcite, usually less than half an inch in thick-

ness, which sometimes show slight symmetrical banding. In thin sections under the microscope the lenses of siderite are seen to be stained with limonite and to contain numerous inclusions of quartz and a few grains of iron oxide and sulphide. The ground-mass is composed essentially of quartz, sericite, and carbonate, with lesser amounts of pyrite, pyrrhotite, iron oxide, chiefly hematite, acid plagioclase feldspar, dark brown prisms of tourmaline, zircon, and a little chlorite.

Schists that are identical in every way with the specimen just described occur within 200 yards of the bridge and are interbedded with the quartzites. Near the bridge, which is about 1,000 yards from the contact, biotite and chlorite begin to take the place of the siderite in the lenticular knots, and it is believed that these changes are chiefly due to the metamorphic action of the granite. From this point eastward the schists show rapidly increasing evidence of contact metamorphism.

A specimen (49)[a] from the bluffs about 25 yards west of the bridge is, megascopically, closely similar to the schists already described, but under the microscope it may be seen that many of the knots are composed of biotite, chlorite, and quartz instead of siderite. Lenses of siderite, stained with limonite, are however still present. The ground-mass contains sericite, quartz, chlorite, biotite, pyrite, iron oxide (hematite?), a few small prisms of green and brown tourmaline, zircon, and probably a little feldspar.

A specimen of knotted schist (307) obtained from the bluff 400 yards southeast of Bremo bridge and about 800 yards from the contact, contains numerous rounded crystals of biotite, averaging 1 to 1.5 mm. in diameter, and, rarely, small pink garnets of nearly the same size. The crystals of biotite are dark brown to black in color and the direction of cleavage, which is independent of the schistosity of the rock, shows no regular orientation. They closely resemble the crystals of ottrelite which sometimes occur in similar schists. The ground-mass is slightly coarser in texture than the specimens previously described, and the minerals—quartz, mica, and magnetite—can be distinguished megascopically.

Under the microscope, as shown in Pl. V, fig. 1, the crystals of biotite are seen to have an irregular, ragged outline and a micropoikilitic texture due to the numerous inclusions of quartz. In places these inclusions are so plentiful that they give to the mica an appearance resembling lace-like network. The biotite is dark brown in color and strongly pleochroic. The ground-mass is composed essentially of quartz and sericite with a little

[a]Specimen collected by Dr. T. P. Maynard.

chlorite, biotite, less magnetite, and, rarely, plagioclase feldspar. The quartz occurs in elongated grains, interleaved with fine shreds of sericite, all being perfectly oriented parallel to the schistosity. The small grains of magnetite show a similar elongation parallel to the schistosity, and the slide also contains clouds of uniformly distributed, dust-like inclusions, probably black iron ores, though they are too small to make identification positive. The shreds of sericite, over large areas, extinguish simultaneously except where they curve around the large biotite crystals, and there the change is gradual. This gives the thin section a brilliant appearance between the crossed nicols. Where the flakes of sericite curve around the biotite crystals they are pushed close together, and the interstitial quartz, which has been largely removed from these points, is concentrated immediately in front and behind the biotite, in grains that are somewhat larger than those of the ground-mass.

In passing eastward toward the contact, the crystals of biotite present in the lenticular knots gradually give way to garnets, and the ground-mass becomes a little coarser. At a distance of about 600 yards southeast of the bridge the garnets are numerous and well developed, while the biotite crystals are absent or only sparingly present. Within less than 100 yards from this point the rocks are close-textured, less easily cleavable, and contain much hornblende (see p. 109). A specimen in which the garnets greatly predominate over the biotite crystals (319-A) was obtained from the Johnson mine near New Canton, and is described in detail on pages 254-255.

Rogers described the schists in the vicinity of Bremo under the name of bird's-eye maple slate. His statement is as follows:

"After leaving the gneiss and hornblende slate a little below Bremo, we come upon heavy vertical beds of a *Micaceous slate,* in which are multitudes of half-developed garnets, and sometimes crystals of cubical pyrites —giving to the surface of the rock the appearance of numerous knots, around which the fibres of the stone are beautifully curved, so as closely to resemble the shading of the bird's-eye maple."[a]

The belt of knotted schists, that has just been described, extends from the river in a northeasterly direction for a distance of over 6 miles. At the Snead mine, a mile north of Fork Union, a knotted schist is exposed which contains pseudophenocrysts of both garnet and biotite. The belt extends as far south as Willis Mountain and possibly much farther, but good exposures are seldom found after leaving the river. The belt of knotted schists passes just west of Gravel Hill, and crosses the road about

[a]Rogers, W. B., Geology of the Virginias, 1884, p. 78.

1½ miles south of Dillwyn. In this southern portion of the area, the knots in the schist do not seem to be as well developed as farther north, but this may be more apparent than real, for all of the rock examined was partly decomposed.

Strathmore.—On the west side of Bremo Creek, about 1,000 yards west of Strathmore, there is an outcrop of knotted schist containing well-developed lenticular eyes of siderite. The rock is more schistose than the similar schists a mile west of Bremo bridge, but it is otherwise the same. It outcrops at several points to the northeast and apparently extends for a distance of 5 miles or more in that direction, but on the south side of Slate River it was not found. This belt of knotted schists, while separated from the one that was first described by the intervening Ordovician formation, undoubtedly belongs to the same series and owes its present position to folding and faulting.

The Tellurium schists.—The third belt of knotted schists outcrops in the road at Shannon Hill and may be traced in a southwest direction nearly to Big Byrd Creek. It is best exposed in the underground workings at the Bowles, Tellurium, and Scotia mines. A representative specimen (178) from the Tellurium mine is described on pages 168-169, and a photomicrograph is shown in Pl. V, fig. 2.

Stage Junction.—A bed of micaceous schist, about 300 yards wide, is exposed near Stage Junction. It has a strike of N. 20° E., dipping nearly vertical, and was traced for over 1½ miles. No fresh specimens could be obtained, but the weathered material indicates that the rock is similar to the knotted schists found elsewhere in the area.

Hornblende Schists.

GENERAL CHARACTER AND DISTRIBUTION.

Hornblende schists, that are unquestionably sedimentary in origin, occur at a number of places in the pre-Cambrian area, but the origin of many of the hornblende schists is doubtful, and most of them are probably derived from igneous rocks. Because of the general character and structural relations of these rocks, as well as their distribution relative to the later granites, it is believed that the formation of hornblende schists from sedimentary rocks was due chiefly to contact metamorphism, rather than to regional dynamic metamorphism. Hornblende schists are commonly present along the contact between the igneous and sedimentary rocks; and the few outcrops that were found at a distance from known

occurrences of granite, may be explained by lack of exposures, though in some localities it is possible that erosion has not yet progressed far enough to expose the underlying granite.

As it is seldom possible to distinguish between the hornblende schists that are sedimentary in origin and those that are igneous in origin, and as the majority of these rocks belong to the latter class, most of the occurrences will be described under igneous rocks.

DETAILS OF OCCURRENCES.

New Canton.—One of the best exposures of hornblende schist is furnished by the bluffs along Phelps Creek in the vicinity of New Canton. These schists occur along the contact between the sedimentary schists and quartzites on the west, and the granites and their accompanying differentiates on the east. Since this is the best exposed section crossing the contact, and since the schists that are sedimentary in origin grade, without noticeable change, into the hornblende schists that represent a basic border facies of the granite, a detailed description of all the rocks in the immediate vicinity of the contact will be given under the discussion of contact metamorphism (see pp. 109-112), and nothing further need be said here concerning them. These same hornblende schists are well exposed at the Johnson mine and are described on pages 248-250 and 255-256.

Big Byrd Creek.—At the horseshoe bend in Big Byrd Creek, three-quarters of a mile east of Stage Junction, there is an outcrop of fine-grained hornblende schist, which is believed to be sedimentary in origin. The strike of the formation at this point is N. 35° E. and the dip is 40° S. E. The schist has a well-developed slaty cleavage, which is so marked that it led the owner of the property to prospect the outcrop in the hopes of developing good roofing slate. A garnetiferous quartz-mica schist occurs on the west side of the hornblende schist, and a short distance to the east there are outcrops of quartz-sericite schist. A large dike of diabase cuts the schists about 200 yards from the creek, but has in no way affected the rocks with which it is in contact.

Megascopically the rock is dark gray to green in color, with a fine-grained, even-granular texture, and in places the cleavage planes show lens-shaped spots or blotches, 0.5 cm. in length, which are composed of biotite and chlorite. Small needles of black hornblende and white granular quartz are the principal constituents distinguishable by the naked eye, but some of the rock contains considerable evenly distributed biotite. Occasionally the schist is banded in light- and dark-colored layers parallel to the schistosity; the dark-colored layers being due to the presence of much hornblende and biotite, and the light ones to an excess of quartz. A little pyrite may also be identified in places.

In thin section (Spec. 51) under the microscope the rock is seen to be composed of dark green hornblende, quartz, feldspar, magnetite, biotite, and chlorite. The hornblende occurs in narrow prismatic crystals, ranging up to 2 mm. in length, which show good cleavage and strong absorption, the colors being various shades of brown, blue, and green. The quartz and feldspar are present in small clear grains, filling the interstices between the hornblende, and they occasionally contain small included needles of hornblende. The quartz and feldspar have the same index of refraction and are distinguishable with difficulty, except where the latter mineral shows evidence of cleavage. The magnetite occurs in clusters or aggregates of small irregular grains. The biotite is greenish-brown in color and shows partial alteration to chlorite.

Lantana.—The contact between the igneous and sedimentary rocks crosses the road about half a mile southeast of Lantana, and it is marked by a belt of hornblende schists that are similar to those occurring near New Canton. Exposures of fresh rock are rare in this vicinity, but along the branch, a mile northeast of Lantana, there are several outcrops of hornblende schist.

A partly decomposed rock, outcropping on the left bank, is medium coarse-grained and dark green in color. The mineral constituents recognizable megascopically are dark green hornblende, quartz, probably feldspar, and a little garnet, and chlorite. A prismatic mineral (probably tremolite), which is light green to brown in color, is also present.

A specimen (90) obtained from the opposite side of the branch is finer grained and much fresher. It is an even-granular, dark greenish-gray schist, in which amphibole, quartz, pyrite, and magnetite are the principal constituents. Part of the amphibole is green in color, but much of it is light gray to nearly colorless, and is doubtless tremolite. In thin sections under the microscope, the amphiboles are all colorless in natural light, and between the crossed nicols most of them show rather high interference colors. Twinning is sometimes shown. There is also a little acid plagioclase present, which is usually unstriated and therefore difficult to distinguish from the quartz.

Gneisses.

GENERAL CHARACTER AND DISTRIBUTION.

Gneisses, believed to be sedimentary in origin, are found only in one portion of the area of pre-Cambrian rocks, namely, along the eastern border, north of James River, in the vicinity of Lantana. These gneisses are best exposed along Big Byrd Creek, between Bowles' bridge, 1½ miles

northeast of Stage Junction, and the contact of the sedimentaries with the granites, nearly two miles below. Away from the creek there are few outcrops; but float is present in many places, being especially abundant near the branch 1¼ miles northeast of Lantana, and the underground workings of the Young American mine furnish excellent exposures of fresh material. All of these gneisses are confined to the area of metamorphosed sedimentaries lying on the southeast side of an imaginary line, which extends from a point on Big Byrd Creek, a few yards above Bowles' bridge, in a northeast direction through Pryors Crossroads. No knotted schists are found on the southeast side of this line. It appears certain that the areal distribution of the sedimentary gneisses was once much greater than at present, and they probably extended for a considerable distance toward the northeast and the southeast; but the greater part of these beds has long since been removed by erosion.

Two principal varieties of gneiss were recognized—one light in color and composed for the most part of quartz, feldspar, and sericite; the other dark-colored because of the presence of more or less biotite and dark green hornblende. Both usually show well-developed banding. These two varieties occur interbedded with one another, and with beds of sericite quartzite, ferruginous quartzite, and quartz-sericite schists. The dark-colored gneiss is confined to the northwestern side of the belt and is the dominant rock exposed in the openings at the Young American mine, but its areal distribution is not so extensive as that of the lighter variety.

GENESIS.

The manner in which these gneisses are interbedded with one another and with the quartzites, leaves no doubt as to their sedimentary origin. Anaylses of both the dark- and light-colored gneisses, made from samples taken 100 feet below the surface at the Young American mine, are given on page 124. The analyses show a striking resemblance in chemical composition between these metamorphosed sedimentaries and igneous rocks of the quartz-diorite family. It is therefore probable that the sediments were derived from a land area composed chiefly of such rocks, and that they were laid down in comparatively shallow waters close to the shore. The conditions under which such material was derived did not permit mature decomposition; the land area was probably poorly covered by vegetation, rock disintegration was rapid, and the material formed was quickly removed and redeposited without appreciable sorting. The sediments laid down in this manner formed beds of arkosic sandstones and grits; and the present character of the rocks is due to dynamic regional metamorphism, aided by the intrusion of the granitic rocks that partly surround and probably underlie these altered sediments at no great depth.

DETAILS OF OCCURRENCES.

Young American mine.—The freshest exposures of both the light and the dark varieties of gneiss were found in the lower workings of the Young American mine; and detailed megascopic and microscopic descriptions of these rocks, together with chemical analyses, are given under the description of this property (see pages 122-139). The difficulty of obtaining fresh material—for microscopic study and chemical analysis—may be appreciated when it is stated that, in the Young American mine, some of the rock is badly decomposed to a depth of nearly 100 feet below the surface.

Bowles' bridge.—On the road between Stage Junction and Pryors Crossroads, near the bridge over Big Byrd Creek, there are well-exposed outcrops of light gray gneiss. The rock (Specs. 39 and 40) is fine-grained, even-textured, and slightly banded; both in the hand specimen, and in thin section under the microscope, it closely resembles a fine-grained granite-gneiss. It is composed essentially of quartz, orthoclase and acid plagioclase feldspars, and sericite. Much calcite, probably secondary in origin, can be distinguished under the microscope; biotite is present in small dark green flakes, partly altered to chlorite; and small amounts of pyrite, magnetite, and zircon constitute the minor accessories. Some of the quartz grains show undulatory extinction, but for the most part there is little evidence of optical distortion or granulation. The sericite occurs in fairly large flakes, containing numerous inclusions of quartz, and it is partly of later origin than the schistosity.

About 400 yards below the bridge there is an outcrop of dark gray gneiss (Spec. 35), which is apparently identical in mineral composition as well as in texture with much of the rock exposed in the Young American mine. It is fine-grained, closely banded in layers of light and dark minerals, and composed for the most part of quartz, feldspar, biotite, chlorite, sericite, and occasional garnets. Elsewhere in the same vicinity the rock contains much dark green hornblende.

Bertha and Edith mine.—On Big Byrd Creek, about 1,000 yards south of Bowles' bridge, there is an exposure of light gray gneiss (Spec. 32) similar in appearance to that at the bridge, except that it is slightly coarser grained. Much of the sericite occurs in large flakes in which the cleavage is not parallel to the schistosity, showing that it is of later formation than the movements which metamorphosed the sediments. The minerals present, in the order of their relative abundance, are quartz, feldspar, chiefly acid plagioclase, sericite, biotite, chlorite, magnetite, pyrite partly altered to limonite, zircon, and titanite. Calcite was not identified.

On Big Byrd Creek, a mile south of Bowles' bridge, the gneiss (Spec. 30) is a light gray, fine-grained rock, differing but little from the specimens previously described. It contains less sericite, and under the microscope considerable epidote or zoisite can be detected.

Where the road entering the property crosses Great Camp Branch, there is an outcrop of the light gray gneiss, which is within about 300 yards of the contact of the sedimentaries with the granite. The rock (Spec. 48) is composed of quartz, feldspar, and sericite, with lesser amounts of biotite, partly altered to chlorite, garnet, zircon, and magnetite.

Belzoro mine.—Near the branch half a mile north of Lantana, there are numerous pieces of the light gray gneiss lying loose on the surface, but there are no outcrops of rock in place. The same material is plentiful in the vicinity of the other branch, nearly a mile to the northeast. This gneiss (Spec. 85) is slightly banded, and, except for the sericite, is fine-grained. Some of the areas of sericite are a centimeter in diameter, and as the orientation of the cleavage is independent of the schistosity of the rock they must be of later formation. Even in the hand specimen the flakes of sericite are seen to be full of included quartz grains. Under the microscope the rock is seen to be composed chiefly of quartz, sericite, feldspar, with lesser amounts of biotite, partly altered to chlorite, epidote, garnet, magnetite, zircon, and rutile needles. Some of the feldspars show partial alteration to sericite, and this is probably the chief source of the mica. In places the sericite shows intergrowths with biotite. Zircon and rutile needles are very plentiful as inclusions in some of the quartz.

ORDOVICIAN.

General Statement.

The Ordovician rocks are for the most part confined to a long narrow belt, which extends in a northeasterly direction from a point near Alpha, a station on the Buckingham Branch of the Chesapeake and Ohio Railway, to Carysbrook, a station on the Virginia Air Line Railway. A small elongated area of the same formation, located along the upper portion of Long Island Creek, between Palmyra and Wilmington, is in approximate alignment with the larger belt; and it seems most likely that the two areas were formerly continuous, and that they have been separated by the erosion of Rivanna River, which has removed the overlying sedimentary rocks, exposing the granite beneath.

Another small area, which parallels the main belt for a short distance, has been prospected for slate at a point about 2 miles north of Fork

Union Station. It was undoubtedly connected at one time with the main area, and has become separated through folding and erosion.

The principal belt has a maximum width near James River of over a mile, but it probably averages less than half a mile; the total length, including the detached area on the northeast side of Rivanna River, is about 22 miles.

The Ordovician series, where complete, consists of a thin bed of conglomerate, overlain by a few feet of impure quartzite, and then followed by several hundred feet of slate. In places the conglomerate is composed of mashed pebbles of pre-Cambrian schist, and when these are small, the fragmental character of the rock is distinguishable with difficulty. At one point a layer of tuffaceous material, a few feet thick, occurs interbedded with the slates.

The discovery of crinoids in slate from the Arvonia quarries was announced in 1892, and from a study of these fossils Dr. Walcott reached the conclusion that they belonged to the Trenton-Lorraine or upper portion of the Ordovician fauna.[a] Later brachiopods and trilobites were found, and, according to Dr. R. S. Bassler, the twelve species which have been identified "make up an assemblage of forms which seems to be of middle Cincinnatian age."[b]

Conglomerate.

GENERAL CHARACTER AND DISTRIBUTION.

The conglomerate occurs only at the base of the Ordovician rocks, where it rests upon the eroded surface of the metamorphosed, pre-Cambrian sediments and in places upon the granite. On the south side of James River the conglomerate is found along the southeastern boundary of the slate area, but has not been observed on the northwest boundary. It is not exposed in the section furnished by the bluffs along the river, probably because of minor faulting, which is very marked in the vicinity of the place where the conglomerate would be expected to appear. It outcrops, however, within about half a mile of the bluffs and can be traced southward for a distance of several miles. On the north side of the river the conglomerate was observed only on the west side of the slate, occurring on the road between Palmyra and Wilmington, about a quarter of a mile west of Long Island Creek, and in the railroad cut half a mile south of Carysbrook.

[a]Darton, N. H., Fossils in the "Archæan" Rocks of Central Piedmont, Virginia, Amer. Jour. Sci., 1892, vol. xliv, pp. 50-52.

[b]Watson, Thomas L., and Powell, S. L., Fossil Evidence of the Age of the Virginia Piedmont Slates, Amer. Jour Sci., 1911, vol. xxi, pp. 33-44.

The lack of suitable exposures makes it impossible in most places to determine the thickness of the conglomerate. Outcrops in the vicinity of Penlan indicate a possible thickness of perhaps 100 feet, but as the dip of the strata could not be determined at this point, the measurement means little. In the railroad cut south of Carysbrook the conglomerate is only a few inches thick and in places entirely disappears.

The composition of the conglomerate varies greatly in different portions of the area; in places it consists almost entirely of flattened pebbles of schist, but pebbles of vein quartz and of quartzite are usually present, and sometimes there is much magnetite, graphite, and other material. No granite or feldspar pebbles were found. The rock is usually schistose and, where the quartz pebbles are scarce, is easily mistaken for a pre-Cambrian schist. The pebbles of vein quartz show no pressure effects, those of quartzite are usually more or less distorted, and all the softer material is pressed out flat.

DETAILS OF OCCURRENCES.

Penlan.—There are prominent outcrops of conglomerate along the county road about three-quarters of a mile southeast of Penlan. The rock contains well-rounded pebbles of quartz and also of quartzite, ranging up to 2 or 3 inches in diameter; but for the most part it consists of a fine-grained schistose ground-mass, which has been derived from pebbles of the neighboring pre-Cambrian schist. In places it is possible to distinguish flattened and almost obliterated fragments of quartz-sericite schist and of the slate-colored, knotted schist.

When the schistose ground-mass is examined under the microscope (Spec. 462), clear rounded grains of quartz, ranging up to 1.5 mm. in diameter, can be distinguished in a ground-mass consisting chiefly of sericite, chlorite, quartz, and black oxide of iron. The larger quartz grains seem to have grown slightly at the expense of the surrounding material, for they have irregular outlines, with little spurs running out into the ground-mass, and frequently contain numerous inclusions along their border portions. Gas and fluid inclusions are plentiful in some of the quartz. Glistening plates of hematite, and a few grains of magnetite make up the remaining accessories.

Outcrops of conglomerate similar to that just described are exposed along the road running northeast and southwest, about half a mile southeast of Arvonia, and at numerous other points along the same line of strike.

Carysbrook.—In the railroad cut half a mile south of Carysbrook, the Ordovician sediments can be seen resting directly on the eroded surface of the granite (see Pl. VI, fig. 1). There is in most places a thin line of pebbles in contact with the granite, but sometimes even this is absent.

A bed of impure quartzite, about 10 feet thick, rests on top of the conglomerate, or where this is absent on the granite, and above the quartzite occurs the slate. The pebbles are chiefly of quartz, but fragments of slaty rock are present, and also much graphitic material. The latter is soft, disintegrating rapidly, and leaving cavities in the weathered surface. The pebbles are cemented together by fine-grained, impure quartzite.

Long Island Creek.—There is an outcrop of highly ferruginous conglomerate on the road between Palmyra and Wilmington, about a quarter of a mile west of Long Island Creek. The rock is dark gray, very schistose, and consists of flat, lens-shaped pebbles of quartzite, in a chloritic groundmass, containing a large amount of fine-grained magnetite. Under the microscope (Spec. 486) the magnetite apparently constitutes 40 or 50 per cent. of the mass, the remainder being made up of quartz, chlorite, and sericite, in the order named. The smaller grains of magnetite are commonly idiomorphic, but the larger grains, ranging up to 1 or 2 mm. in diameter, are irregular in shape.

Quartzite.

The best exposure of Ordovician quartzite is the one which may be seen in the railroad cut, half a mile south of Carysbrook. The rock is only about 10 feet thick and varies somewhat in texture. It is nearly even-granular, slightly schistose, and of a light bluish-gray color. In thin sections (Specs. 509 and 510) under the microscope, the quartz grains show optical distortion and some granulation, and they have partly recrystallized so as to fill the interstitial spaces. They contain liquid- and gas-filled cavities, and small black inclusions (iron oxide?) arranged in lines which pass across the quartz grains. In places these lines are very numerous, suggesting fractures that have been recemented. Sericite is the principal impurity, and there are occasional short prisms of brown tourmaline. Zircon and small rutile needles occur as inclusions in some of the quartz.

A bed of quartzite also outcrops in the road about half a mile southeast of Penlan, but its thickness could not be determined. It is separated from the conglomerate described on page 41 by a bed of schist which is probably formed chiefly from fragments of the pre-Cambrian schist.

Schist.

A light gray schist, closely resembling some of the pre-Cambrian schists, outcrops in the road about half a mile south of Arvonia, and not

Fig. 1.—Ordovician sediments resting on eroded surface of massive granite near Carysbrook. A thin line of conglomerate runs between the hat and hammer.

Fig. 2.—Looking north along summit of Willis Mountain. Piedmont peneplain in background.

ORDOVICIAN SEDIMENTS ON GRANITE, AND WILLIS MOUNTAIN.

Fig. 1.—Bed of tuff in Ordovician slates. Bluffs on the south side of James River.

Fig. 2.—Fault in Ordovician slates. Bluffs on south side of James River.

BED OF TUFF AND FAULT IN ORDOVICIAN SLATES.

far from the conglomerate. The rock is clearly fragmental in origin and exhibits two directions of cleavage—one due to bedding, and the other to pressure—which intersect at an angle of about 40°. It is composed essentially of quartz, sericite, and chlorite, and contains occasional lenticular eyes of quartz 1 to 2 mm. in diameter. Under the microscope (Spec. No. 1)[a] the lenticular eyes are seen to be partly quartzite, and partly clear grains of quartz, some of which show evidence of enlarged borders. Liquid and gas inclusions, and a little zircon and titanite may also be identified. This rock is similar to the schist which occurs between the conglomerate and the quartzite about half a mile southeast of Penlan.

Tuff.

A bed of tuffaceous material is exposed in the bluff near the eastern border of the slate area and a mile west of Bremo bridge. It is interbedded with black graphitic slates, which in places contain much pyrite. A photograph of the bed is shown in Pl. VII, fig. 1. Close to the hammer a nearly vertical fault can be seen, on the left of which the beds stand almost vertical, while on the right they are much contorted but nearly horizontal. The tuff is the light-colored material near the hammer. No other beds of tuff were identified in the area.

The tuff (Spec. 494) is a fine-grained, gray, slate-colored rock, distinctly fragmental to the naked eye, and very schistose, so that the fragments are drawn out in long streaks. Fine flakes of sericite, small grains of quartz, and a little pyrite are the only minerals distinguishable megascopically. Under the microscope it is seen to consist chiefly of fine-grained quartz, sericite, with numerous larger grains of quartz, averaging less than 0.5 mm. in diameter, and occasional small phenocrysts of feldspar (orthoclase and acid plagioclase). Calcite is plentifully distributed through the section, and pyrite partly altered to limonite, occurs in small grains. Very fine, dust-like inclusions (graphite or iron oxide) are abundant throughout the slide.

Slate.

GENERAL CHARACTER AND DISTRIBUTION.

Slate is the dominant rock of the Ordovician series of sedimentaries, and the beds probably have a thickness of more than 1,000 feet, but because of the complicated folding and faulting only a rough estimate can be made. The areal distribution of the slate is coincident with that of the formation as a whole, for the thickness of the other members is insignificant in comparison with that of the slate.

[a]Microscopic thin section made from specimen collected by Dr. T. P. Maynard.

The slate has a finely granular, crystalline texture, it is dark gray to black in color, and usually has a rather rough though very lustrous cleavage surface. It is graphitic and usually slightly magnetitic, contains a little pyrite, does not effervesce in cold dilute hydrochloric acid, and is very sonorous. The degree of cleavability varies greatly in different parts of the area, but is usually high, so that the slate can be split readily into slabs of any desired thickness.

In the vicinity of Arvonia the slate has been extensively quarried for roofing and other purposes, and at a number of places along the strike of the formation prospecting has been carried on with very encouraging results. Because of its highly crystalline character, the slate has great strength and durability, and some of it, used in roofing buildings over a century ago, shows no discoloration from its long exposure. All of the slate in this area is not, however, available for commercial purposes, as the value of some of it is destroyed by close folding and faulting, and in a few localities the cleavage is not sufficiently developed.

DETAILS OF OCCURRENCES.

A detailed report on the slate deposits of Virginia is now in preparation, and will be published shortly as Bulletin No. X of the State Geological Survey; therefore the following descriptions will be brief, and for the most part limited to facts bearing on the structural relations of the slate formation.

Arvonia.—At Arvonia there are extensive quarries, all of which are located on the east side of the slate belt. In these openings the bedding and cleavage of the slate are identical, striking N. 33° to 37° E. and dipping 70° to 90° southeast. There are three sets of joints, namely, vertical dip joints striking northwest; strike joints, running northeast and southwest and dipping 70° to 80° southeast; and diagonal joints some of which dip 30° east while others dip 55° west. Quartz veins are occasionally present, some of which contain calcite, and a little chlorite and biotite. In one of the quarries a dike of olivine diabase is exposed, which is 12 feet thick and traverses the slate diagonally.

The slate is very dark gray, with a faint greenish hue; it shows a distinctly granular crystalline texture to the naked eye; and has a highly lustrous cleavage surface, which is commonly rough or slightly wrinkled because of the presence of small flakes of biotite and of minute grains of the iron ores. According to Dale[a] the mineral constituents, in the order

[a]Dale, T. N., Slate Deposits and Slate Industry of the United States, Bull. U. S. Geol. Survey, No. 275, 1906, p. 114.

of their relative abundance, are muscovite and sericite, quartz, biotite, carbonate, graphite (or carbonaceous matter), pyrite, chlorite, magnetite, with accessory plagioclase, zircon, hematite, tourmaline, and rutile.

The following microscopic description of the slate from the Williams quarries is given by Dale, and may be taken as representative of the other quarries in this vicinity:

"Under the microscope it shows a matrix of minute alternating beds, chiefly of fine muscovite, with coarser ones, chiefly of quartz, the former with a brilliant aggregate polarization, the latter with a faint one. These beds are parallel to the cleavage. The quartz fragments measure up to 0.085 mm. Scattered throughout both the more micaceous and the more quartzose beds are crystals, lenses, and particles of pyrite, numbering about 25 to each square millimeter and measuring up to 0.09 mm., rarely 0.15 and 0.42, with their longer axes parallel to the cleavage. These probably include a little magnetite. There are also biotite scales transverse to the cleavage, about 22 per square millimeter, and measuring up to 0.12, rarely 0.2 mm. Almost, if not quite, as abundant are plates and rhombs of carbonate. There are occasional scales of chlorite interleaved with muscovite, a few grains of plagioclase feldspar 0.047 mm., rarely one of zircon, some tourmaline prisms 0.014 mm. long, much extremely fine graphitic (or carbonaceous?) material, a few particles of hematite, and some rutile needles. Sections parallel to the cleavage are unusually brilliant in polarized light, owing to the abundance of quartz, biotite, and carbonate."[a]

Bluffs along James River.—The slates exposed in the bluffs along the south side of James River show evidence of much close folding and faulting (see Pl. VII). Near the fault shown in Fig. 2, which is located close to the railroad, 500 yards south of the mouth of Slate River, the slate has two equally developed cleavages intersecting at an angle of about 5°. One of these is the ordinary slaty cleavage due to pressure, and the other is probably slip cleavage due to minute faulting. As the two cleavage surfaces reflect light at slightly different angles, the slate has a very striking appearance. About a quarter of a mile farther east a similar slate is exposed, in which the angle between the two cleavages is 25°, but one is much better developed than the other. It is possible that one cleavage is due to bedding.

Some of the slates are highly graphitic, and in others pyrite is very plentiful, occurring in thin layers parallel to the bedding. Hematite is occasionally present in the form of thin plates, a fraction of a millimeter in diameter.

Carysbrook.—The slate exposed in the railroad cut half a mile south of Carysbrook is wholly lacking in slaty cleavage, but has a distinctly

[a]Dale, T. N., Ibid., pp. 113-114.

schistose structure parallel to the strike of the formation, which causes the rock to break in roughly prismatic shapes. This peculiarity is probably due to the location of the material at the bottom of a synclinal fold, where the pressure was approximately equal in all directions except along the axis of folding.

The strike of the formation is about N. 25° E. and there are three principal sets of jointing, namely, nearly vertical strike joints running northeast and southwest; joints which dip about 30° southeast and are approximately parallel to the contact with the underlying granite; and transverse joints having a strike of N. 60° W. and dip of 75° northeast. The latter are spaced 2 to 8 inches apart.

The slate (Spec. 505) is dark gray, with little luster, and contains numerous flat discs of specular hematite, which are oriented in all directions parallel to the axis of folding. These plates vary in diameter up to 1 mm. and in thickness up to 0.1 mm.

Examined microscopically the chief constituents of the ground-mass are, in the order of their relative abundance, sericite, quartz, chlorite, with accessory tourmaline, and zircon. Some of the quartz occurs in lenticular eyes less than 0.5 millimeter in length, which occasionally contain small fragments of zircon. Prisms of greenish-brown tourmaline, ranging up to 0.2 millimeter in length, are fairly plentiful, and are usually oriented parallel to the schistosity. Some of the thin discs of hematite contain numerous small inclusions of quartz.

TRIASSIC.

The small area of sedimentary rocks shown on the map (Pl. I), between Ca Ira and Willis Mountain, belongs to the Triassic (Newark) system, and is the northern end of the Farmville area, which extends in a southwesterly direction for a distance of over 20 miles. In this northern portion the rocks consist of gently dipping beds of conglomerate, sandstone, and shale. They are deep red in color, and are in marked contrast to the surrounding crystalline rocks, chiefly granite and pegmatite, which weather to a light gray soil. Near Farmville fine, light-colored sandstones and shales occur interbedded with several small coal seams, the lighter color being undoubtedly due to the reducing action of the carbonaceous matter.

The area as a whole is, topographically, a basin surrounded by hills of crystalline rocks, but lack of exposures make it difficult to work out the detailed geologic structure. The stratified rocks of the Triassic rest un-

conformably on the metamorphosed pre-Cambrian sediments and the granites; and these underlying formations dip steeply toward the southeast. The Triassic beds are much disturbed, changing abruptly from northeast to southwest dips, and Russell determined the presence of at least four north and south faults.[a] One of these faults forms the eastern border of the area about 2 miles north of Farmville, and there the stratified rocks are much broken and slickensided. In the absence of better exposures, it is impossible to measure the thickness of the beds, but everything indicates that they are of no great depth.

The rocks of the Triassic system have not undergone the great crustal movements which have so intensely metamorphosed the older rocks of the area; indeed, for the most part, they have not been thoroughly consolidated. Since these rocks have not extensive areal distribution in the region mapped, and since they are of no economic importance, they will not be discussed in this report.

ROCKS IGNEOUS IN ORIGIN.

GENERAL CLASSIFICATION.

The rocks of igneous origin described in this report are classified, in so far as possible, according to their relative age. The position of some of these rocks in the geological column is accurately known, that of others can be determined within comparatively narrow limits, and in a few instances there is considerable uncertainty. As in the case of the sedimentary rocks, the chief criterion used in distinguishing between the pre-Cambrian and the later rocks is that of relative schistosity, while the position of others is determined by their relation to sedimentaries of known age. Under the description of each rock type, the evidence upon which its age classification is based is given in detail. The principal groups into which the igneous rocks have been divided are: (1) Pre-Cambrian, (2) pre-Cambrian and Cambrian, (3) Cambrian or post-Cambrian, and (4) Triassic.

PRE-CAMBRIAN.

Greenstone Schists.

GENERAL CHARACTER AND DISTRIBUTION.

A large area of greenstone schists is present along the northwestern border of the map, given on Pl. I, and extends for several miles to the westward. The southeast contact between these schists and the other pre-Cambrian rocks crosses James River about 1,000 yards west of Strath-

[a] Russell, I. C., Correlation Papers. The Newark System. Bull. No. 85, U. S. Geol. Survey, 1892, pp. 88-89.

more, and continues in a general southwesterly direction for an unknown distance; passing northeast the greenstone schists apparently pinch out in the vicinity of Palmyra. On Slate River, 500 yards west of Hunts Creek, Ordovician slates are apparently in contact with the greenstone schists for a short distance.

Chloritic schists are common in the region between Wilmington and Kent's Store, and occur at several other localities in the area mapped, but as these rocks are derived chiefly from the hornblende schists that are found associated with the granites, they will be described under that heading.

The rocks in the large area of greenstone schists vary in texture from dense aphanitic varieties to those that are medium fine-grained, and in places porphyritic. They usually show a pronounced schistose structure but some of the coarser grained rocks, which have undergone less alteration, are more nearly massive. The color is always green, and varies in shade according to the relative amounts of chlorite and epidote present in the rock.

The mineral constituents present in these rocks are quartz, chlorite, epidote, amphibole, calcite, plagioclase, magnetite, pyrite, and in some instances small amounts of rutile, ilmenite, and titanite. Very rarely a little chalcopyrite or malachite can be identified.

Quartz and usually calcite are present in the ground-mass of the rock and these minerals also frequently occur as eyes and veinlets. The feldspars, and part of the quartz and magnetite, are the chief primary minerals that remain unaltered. The feldspars are basic plagioclase, and frequently show Carlsbad as well as albite twinning. Chlorite is abundant in all of the rocks, occurring in fine-grained dark green scales. Epidote is most plentiful along fracture lines, and it also occurs in some of the veinlets.

Small slickensided surfaces are common throughout the rock; they run in various directions but are usually approximately parallel to the schistosity. They are probably to be explained by the volumetric expansion which has resulted from the alteration of the rock, with the formation of hydrous from anhydrous silicates.

Microscopic examination of a large number of thin sections of the greenstone schists, shows that they are derived from basic igneous rocks, but the alteration has been so extensive that in most cases it is impossible to determine their original character. The texture in a few localities suggests that part of the schists were formed from massive rocks of deep-seated origin, but it is not improbable that they are largely derived from basic lava flows.

AGE.

The intense regional metamorphism which has affected all of the older rocks, and the lack of suitable exposures along the contact, make it impossible to determine the relation of the greenstones to the other pre-Cambrian schists. When the surrounding portions of the Piedmont province have been mapped in detail some light will probably be shed on this question, but at present it is not even possible to make a statement concerning the relative age of the two formations. At the London and Virginia mine (see pp. 185-186) a chloritic schist is interbedded with the quartz-sericite schists but it is different in appearance and has probably had a different origin. The greenstone schists are classified as pre-Cambrian in age because of their extensive metamorphism under dynamic conditions, and because of the presence of gold-bearing quartz veins believed to be Cambrian in age. They resemble the Catoctin schist of the Blue Ridge and may be contemporaneous in age.

DETAILS OF OCCURRENCES.

Slate River.—The bluffs along Slate River, west of the mouth of Hunts Creek, furnish some of the best exposures of greenstone schist that are to be found in the district, and this section will be described in detail. The contact between the Ordovician slates and the greenstone schists crosses Slate River about 500 yards west of Hunts Creek, but is not exposed. On the south bank of the river just west of the contact there is a bold, cliff-like outcrop of the schist.

The rock (Spec. 495) is dark green, fine-grained, even-granular, and not quite as schistose as in most localities. Quartz, chlorite, and a few small cubes of pyrite are the only minerals recognizable megascopically. Under the microscope the rock is seen to be composed of quartz, chlorite, plagiocase feldspar, calcite, talc, epidote, and a little fine-grained magnetite. The quartz grains are slightly larger than the other minerals, and are frequently arranged in irregular lines and flat lenses parallel to the schistosity. The feldspars are ragged in outline and show extensive alteration to the secondary minerals of which the rock is chiefly composed. The chlorite and other minerals are very fine-grained.

A few yards farther west the rock (Spec. 448) is slightly finer grained, more schistose, and contains occasional lenticular eyes of fine-grained white quartz 3 or 4 mm. in diameter. Examined under the microscope the lenticular eyes are seen to consist of clear rounded, interlocking grains of quartz, which contain small gas- and liquid-filled cavities and numerous

rutile needles. Basic plagioclase feldspars are present, some of which show fractures filled with a fine-grained ground-mass, consisting chiefly of chlorite. Calcite, epidote, and zoisite make up the remaining mineral constituents.

Greenstone schists, essentially similar to those just described, continue for several miles up the river with only a little variation here and there. In one place a peculiar veinlet (Spec. 449) about a quarter of an inch wide, was seen cutting the schist. It consists of dark green micaceous chlorite, with cleavage parallel to the walls, and phenocrysts of white feldspar, 3 to 4 mm. long, which project out from the walls of the veinlet. The feldspars show twinning after both the Carlsbad and the albite laws. Nearly a mile west of the creek, a light green rock outcrops which is nearly massive in texture. It is medium coarse-grained, and is composed for the most part of light green hornblende and feldspar. The hornblende is partly altered to chlorite. It is evidently an igneous rock (probably diorite), which has been only slightly altered.

At the Lightfoot mine, on the southeast side of Slate River, 2 miles northwest of Arvonia, the country rock is the typical greenstone schist found everywhere in this section. It is described in detail on pages 241-242.

Lightfoot farm.—On the farm of P. W. Lightfoot, 1¾ miles N. 15° E. of Arvonia, an 18-foot shaft has been sunk in prospecting for copper. Most of the rock exposed on the dump is a fine-grained greenstone schist containing scattered crystals of pyrite, less than 0.5 mm. in diameter, and much fine-grained magnetite. In places there are small segregated areas containing pyrite in coarse, irregular crystals associated with white quartz. A few pieces of rock were seen which contained partly altered phenocrysts of feldspar, 2 cm. in length.

At several points in this vicinity a few small specks of malachite can be seen in the country rock. Pebbles of magnetite are found on the surface in places where they have weatherd out from the greenstone.

Anaconda mine.—The greenstone schist at the Anaconda mine, near Eldridge Mill, is described on page 244. About 400 yards northeast of the mine several small surface openings have been made in prospecting for asbestos. Some chlorite schist is exposed in these pits, but most of the rock is a light green talc which usually contains a few scattered needles of amphibole, probably actinolite. In places there are large masses of amphibole asbestos, part of the fiber being 7 to 8 inches in length, but much of it is cut by joint planes spaced about 2 inches apart. Masses, composed chiefly of actinolite in more or less radiating crystals, are present

on the dump. Magnetite in small grains is scattered through both the chloritic and talcose schists.

Shores.—A quarry for railroad ballast is located on the Chesapeake and Ohio Railway about three-quarters of a mile southeast of Shores. The rock exposed is dark green in color, fine-grained, and is cut by numerous small segregation veinlets consisting of white, fine-grained quartz, and a little calcite and dolomite. These veinlets do not have sharp, well-defined walls but pass by gradation into the schist. The minerals present in the rock, which can be identified megascopically, are quartz, chlorite, calcite, magnetite, and epidote. The greenstone schist extends westward beyond Shores.

Hughes mine.—The gold veins at the Hughes mine, which is located on the Virginia Air Line Railway, 2 miles northeast of Fork Union station, occur in an area of greenstone schist. Specimens of the wall rock from this mine are described in detail on pages 182-183.

Palmyra.—In the vicinity of Palmyra and northwest from the town a greenstone schist is exposed, and in places the chloritic schists enclose masses of talc and steatite which have been worked to a limited extent. It is reported that a little copper ore was found on the west side of Rivanna River opposite Palmyra, occurring in greenstone schist similar to that near the Lightfoot mine.

Quartz-Feldspar Porphyries.

A series of quartz-feldspar porphyries are exposed along Rivanna River about a mile south of Palmyra. These rocks vary from light to dark gray in color and from fine- to medium-grained; they are usually porphyritic to the naked eye, containing feldspar phenocrysts and eyes of blue opalescent quartz; and they all exhibit varying degrees of schistosity. In thin section under the microscope they are seen to consist essentially of quartz, potash and soda-lime feldspars, and certain secondary minerals such as sericite, calcite, chlorite, and epidote. The eyes of quartz usually show strain shadows, more or less fracturing, and granulation; and they frequently contain rutile needles and gas- and liquid-filled cavities. The potash feldspars include both orthoclase and microcline, and these as well as the acid plagioclase are extensively altered with the production of the secondary minerals mentioned above. There is also a little microperthite in some of the rock. The minor accessories comprise magnetite, ilmenite partly altered to leucoxene, titanite, and pyrite.

Rocks similar to these porphyries were not found elsewhere in the area mapped. It is possible that they are genetically connected with the in-

trusive granites, but no evidence in support of this supposition could be discovered. For the most part these porphyries are more schistose than the granites and therefore they are probably older.

Rhyolites.

GENERAL DESCRIPTION AND AGE RELATIONS.

Rhyolites occur interbedded with schists and other rocks at several points near the western border of the area mapped, but they are of no importance as geologic formations. They are light gray, hard, dense-textured rocks, and all show a schistose or slaty cleavage, which becomes more marked in the weathered specimens. Watson and Powell noted the occurrence of these rocks south of James River in the Arvonia slate belt and described similar ones in the Quantico slate belt, where they occur interbedded with the slates which are Ordovician in age.[a] The rhyolites in the James River section may be contemporaneous with those in the Quantico belt, but the writer found no evidence to indicate that this is true. Because of their marked schistosity they are here described with the pre-Cambrian rocks, although it is possible that they are younger.

DETAILS OF OCCURRENCES.

Bremo Bluff.—On the south side of James River, about three-quarters of a mile west of Bremo bridge, there is an exposure of rhyolite, about 20 feet thick, which is interbedded with knotted schists. The rock is light gray, dense-textured, and in places contains elongated spots due to gas cavities or to some mineral which has undergone decomposition. It has a slaty cleavage, which, while scarcely noticeable in the fresher specimens, becomes very prominent in the weathered rock. Under the microscope (Spec. 493) the rock is distinctly schistose and is seen to be composed of quartz, feldspar, biotite, chlorite, black iron oxide, partly magnetite, sericite, zircon, tourmaline, titanite, and small areas of glass.

Slate River.—On the south side of Slate River about half a mile west of Hunts Creek there is a small outcrop of siliceous rock (Spec. 450), which is hard, close-textured, white in color, and very schistose. It is probably a metamorphosed rhyolite. This rock occurs in the area of greenstone schists derived from basic igneous rocks.

Ballinger Creek.—About 1¾ miles east of Palmyra on the road to Wilmington, and 200 yards east of Ballinger Creek, there is an outcrop

[a] Watson, Thomas L., and Powell, S. L., Fossil Evidence of the Age of the Virginia Piedmont Slates, Amer. Jour. Sci., 1911, vol. xxxi, pp. 33-44.

of rhyolite which is closely similar to the rock found west of Bremo bridge. It is slightly more schistose in the hand specimen (485) and in thin section under the microscope it is seen to be porphyritic, containing phenocrysts of quartz and acid plagioclase feldspar about 0.25 mm. in diameter. The quartz eyes contain gas- and liquid-filled cavities. The ground-mass is composed of quartz, feldspar, biotite, chlorite, and sericite.

Palmyra.—A short distance south of the railway station at Palmyra there is an outcrop of schistose rhyolite, in which small eyes of quartz can be distinguished by the naked eye. Examined in thin section (Spec. 14)[a] under the microscope, small eyes of quartz and phenocrysts of orthoclase, 1 mm. in length, which usually show Carlsbad twinning, can be seen in a fine-grained ground-mass, consisting of quartz, feldspar, magnetite, ilmenite partly altered to leucoxene, and a little chlorite and epidote.

PRE-CAMBRIAN AND CAMBRIAN.

Granites, Their Associated Pegmatites and Hornblende Schists.

INTRODUCTORY STATEMENT.

The granites and their associated differentiates, occupying about two-thirds of the area mapped, are confined to the eastern portion (see Pl. I). Similar rocks continue beyond the limits of the map and extend eastward for an unknown distance, for below the falls at Richmond they are covered by the later sediments of the Coastal Plain.

These rocks, while for the most part closely related, belong to several periods of intrusion, and vary in character and mineral composition within comparatively short distances. In composition they range from true granites, in which potash feldspars are dominant over plagioclase, through granodiorites and quartz-diorites, to rocks that are composed almost exclusively of hornblende—every gradation between the two extremes being found. Quartz is always present, the more acid rocks contain muscovite, and biotite usually occurs in all except the most basic varieties, where it is completely replaced by hornblende. With the appearance of hornblende in the rocks the potash feldspars disappear. The dominant rock type of the area corresponds to granodiorite or quartz-diorite in mineral composition. Pegmatites in places accompany the more acid facies, and pegmatitic quartz veins carrying a little mica are also present.

The large granite area occupying the eastern half of the map (see Pl. II) will be divided, for convenience in mapping and description, into

[a]This thin section was made from a specimen collected by Dr. J. S. Grasty.

4 separate divisions or belts, running in a northeast and southwest direction, in each of which the rocks exhibit certain peculiar characteristics. Passing from east to west these subdivisions are (1) the Cartersville area, (2) the Elk Hill complex, (3) the pegmatite belt, and (4) the Columbia area. In addition to these there are several smaller areas which occur within the boundaries of the pre-Cambrian sedimentaries, namely, the Gold Hill area lying between Kent's Store and Tabscott, the Rosney area near the southern border of the map, and an area of unknown but limited extent, in which the only exposures are at the Greeley mine. Each of these areas is described in detail below.

AGE.

The granites are younger than the pre-Cambrian rocks with which they are in contact, but the high degree of schistosity shown by most of the granites is proof of their solidification prior to the cessation of the great crustal movements that preceded the Cambrian. Evidence that the period covered by the intrusion and solidification of the granites continued until after the close of these great movements, is furnished by the fact that the last of the granites to crystallize are practically massive in texture. Similar evidence is furnished by the lack of schistosity in many of the pegmatites and aplites, which are residual differentiates from the granite magma, and are therefore of later crystallization.

Granites crystallize under conditions of deep burial, and therefore much overlying material must be removed by erosion before they are exposed. Near Carysbrook, Ordovician sediments may be seen resting on the eroded surface of almost massive granite, and this indicates that a considerable time interval must have elapsed between the solidification of the youngest granite and the deposition of the sediments in Ordovician time.

A consideration of the facts outlined above leads to the conclusion that the intrusion of the granites probably began during the pre-Cambrian and continued into the early Cambrian. It is not unlikely that the crustal movements which terminated the pre-Cambrian, and the intrusion of the granites, are both manifestations of the same general forces.

Cartersville Area.

GENERAL DESCRIPTION.

The Cartersville area occupies the southeast corner of the map (Pl. II) and its northwestern boundary, passing between Elk Hill and Pemberton, extends in a general southwesterly direction approximately parallel to and

just west of the ridge road leading from Cartersville to Cumberland. There are very few rock exposures in this area except in the vicinity of James River. The outcrops in the bluffs along James River and the occasional exposures found elsewhere indicate that the dominant rock is a fine-grained, light gray granite-gneiss, containing much muscovite and usually a little biotite. Pegmatites are common but the hornblende schists are extremely rare.

DETAILED DESCRIPTIONS.

Pemberton.—On the north side of James River, three-quarters of a mile southeast of Pemberton, there is a large outcrop of gneissic granite. The strike of the schistosity is nearly north and south and the dip about 45° east. There are two varieties of rock exposed at this point; one (Spec. 27) is the light gray muscovite granite which forms the dominant rock type in the Cartersville area; and the other (Spec. 28), underlying the first, is a highly schistose reddish-brown rock.

Examined megascopically, the light gray granite (Spec. 27) is fine-grained and composed of white feldspars, quartz, muscovite in flakes ranging up to 2 or 3 mm. in diameter, a little biotite in small black specks, and rarely small pink garnets. Under the microscope orthoclase feldspar is seen to be dominant over the soda-lime feldspar (probably oligoclase), and no microcline seems to be present; the muscovite is apparently primary; and the biotite is dark brown in color, and strongly pleochroic. Fine hair-like needles of rutile are very plentiful, occurring in feldspar, quartz, and muscovite, but they seem to be most abundant in the feldspars.

The dark-colored gneiss (Spec. 28), which underlies the rock described above, contains occasional lenticular eyes of feldspar and quartz. The rock has a peculiar reddish-brown (almost purple) color due to the presence of much fine-grained, brown biotite. In thin section under the microscope the soda-lime feldspars (probably oligoclase) are seen to be dominant, and there is only a little orthoclase and less microcline present. Some of the feldspars show zonal extinction. The biotite occurs in small light brown flakes and there is also some muscovite. Grains of ilmenite partly altered to leucoxene are common, and hair-like needles of rutile, sometimes curved, are occasionally present, being more numerous in the potash feldspars. A little pyrite and a few small grains of titanite make up the remaining accessory minerals.

A mile northwest of Pemberton, the granite exposed is nearly white in color and almost free of biotite. The minerals recognizable in the hand specimen (25) are white feldspar, quartz, and muscovite, a very

little biotite, and occasionally small pink garnets. Under the microscope the rock is seen to consist of irregular individuals of feldspar, quartz, and muscovite, ranging up to 1 mm. or over in diameter, which are surrounded by and grade into a finer ground-mass, composed largely of quartz and feldspar, and frequently granophyric in texture. Named in the order of their relative abundance, the mineral constituents are potash feldspar (chiefly microcline), quartz, soda-lime feldspar (probably oligoclase), muscovite, and a little biotite. The albite twinning in the plagioclase is very fine and sometimes absent. Around their border portions the feldspars frequently show graphic intergrowths with quartz. The muscovite is partly secondary after feldspar but most of it is probably primary. Only a little biotite is present, occurring in small dark brown flakes which are partly altered to chlorite. The quartz shows strain shadows and contains numerous fluid-filled cavities, some of which have moving bubbles.

Cartersville.—Fresh rock is exposed at a number of places in the vicinity of Muddy Creek and along the road a mile south of Cartersville. Most of it is the light gray muscovite granite, similar to Spec. 27, described above. In the road 200 yards southeast of Muddy Creek there is an outcrop of porphyritic granite. The rock (Spec. 473) contains numerous phenocrysts of white, unstriated feldspar ranging up to 1 cm. in diameter, and in places these feldspars constitute the greater part of the rock mass. They are surrounded by a fine-grained ground-mass of feldspar, quartz, biotite, and muscovite. A similar rock occurs on the opposite side of the river, about halfway between Pemberton and Stokes, where the feldspar phenocrysts range up to 5 or 6 cm. in diameter and are strung out in lines parallel to the schistosity. In some of the rock the large feldspars are so numerous that it resembles a pegmatite rather than a granite porphyry. The dominant rock in this vicinity, as elsewhere in the Cartersville area, is the light gray, muscovite granite. In places it contains pink garnets 0.5 cm. in diameter. At several points the dominant rock is cut by dikes of later granite, 2 or 3 feet in thickness. This later granite is fine-grained, less schistose, and contains more biotite and less muscovite.

Stokes.—One of the few places in the Cartesville area where hornblende rocks occur is located above three-quarters of a mile west of Stokes. At this point there is a small outcrop of fine-grained, even-granular schist, showing slightly gneissic banding, and composed essentially of quartz, feldspar, black hornblende, and epidote. The surrounding rock is chiefly a muscovite granite with occasional outcrops of pegmatite.

Fig. 1.—Flow structure in banded gneiss intruded between layers of hornblende schist.

Fig. 2.—Photomicrograph of plagioclase feldspar in vein quartz from the Waller mine. With analyzer. Magnified 27 diameters. See page 149. Specimen No. 217.

FLOW STRUCTURE AND PLAGIOCLASE FELDSPAR.

Elk Hill Complex.

GENERAL DESCRIPTION.

The Elk Hill complex is made up of three principal rock types—biotite granite, hornblende schist, and pegmatite—which occur interleaved in layers of varying thickness and in places are much contorted. The hornblendic rock appears to have been formed first and the granite intruded into it later, while the pegmatite frequently cuts both of the other rocks. The complex is from one to 1½ miles wide where it crosses James River at Elk Hill, and the best exposures are found in the bluffs three-quarters of a mile below Elk Hill. There are exposures along the road 1½ to 2 miles east of Flanagan Mills, and also in the road just southeast of Fife, but at neither of these localities is it possible to obtain fresh material.

DETAILED DESCRIPTIONS.

Excellent outcrops of fresh rock occur along the bluffs, three-quarters of a mile southeast of Elk Hill, where much blasting was done to make room for the old James River canal. In the photograph shown in Pl. VIII, fig. 1, the straight dark bands are hornblende schist, while the light-colored layers consist of biotite granite and pegmatite. The contortions seen in the layer or dike of granite, which occupies the center of the photograph, probably represent flow structure, for if they were formed by crustal movements occurring after the complete solidification of the rock the layers of hornblende schist would likewise have been affected. The light-colored bands in the granite are pegmatitic in character. Elsewhere in the immediate vicinity the granite may be seen cutting across the hornblendic rock while the veinlets of pegmatite sometimes stop short at the contact and sometimes cut across both rocks.

The hornblende schist (Spec. 22) is dark gray to nearly black in color, and is composed of black hornblende, in crystals ranging up to 2 or 3 mm. in length, white feldspar, and a little black biotite. Small grains of pink garnet can be identified in places. The rock is cut by narrow, irregular veinlets of white feldspar and quartz, and contains lenticular eyes of feldspar 2 cm. and less in diameter. Occasionally a little fine multiple twinning can be distinguished on these feldspars. Under the microscope the hornblende shows perfect cleavage and is pleochroic in shades of light green, greenish-blue, and brown. The feldspars are plagioclase (probably oligoclase) and sometimes show zonal growth; multiple twinning is very fine when present and is frequently absent. There is also

present a little quartz, occasional ragged prisms of tourmaline, numerous rounded grains of titanite, and a little epidote. The thin section is crossed by several microscopic fractures, which branch in places and are filled chiefly with quartz and feldspar.

The granite (Specs. 21 and 23) is a light gray, fine-grained rock, composed essentially of white feldspar, quartz, and a little black biotite, while small pink garnets can be identified in places. It is cut by occasional, irregular, segregation stringers of pegmatitic feldspar and quartz. Fine multiple twinning can sometimes be distinguished on the feldspars. In thin sections under the microscope, soda-lime feldspar is seen to be dominant with the potash feldspars (orthoclase and microcline) present in variable amounts; there are granophyric intergrowths of feldspar and quartz; and both the feldspar and quartz show fracturing and optical distortion. Biotite occurs in small flakes dark green to brown in color, and a little sericite is present as an alteration product of feldspar. Ragged prisms of tourmaline, and occasionally irregular grains of titanite, magnetite, and pyrite make up the accessory minerals. The quartz grains contain numerous fluid inclusions.

In mineral composition this rock corresponds to a granodiorite and is closely similar to the granite (granodiorite) exposed in the quarry at Columbia, an analysis of which is given on page 65. The Elk Hill granite is finer grained and probably contains less quartz than the rock at Columbia.

Passing northeast toward Elk Hill the granite bands become broader, less contorted, and more uniform in composition; and there is much less hornblende schist present. Near Elk Hill the schistosity has a strike of N. 45° E. and a dip of about 45° southeast. The granite exposed near Byrd Creek is similar to that in the Columbia area on the west side of the pegmatite belt.

In places the hornblende schist contains much epidote, and about a mile southeast of Elk Hill some of the rock is composed almost exclusively of light green, granular epidote and white feldspar. In a thin section of this rock (Spec. 26), examined under the microscope, the epidote is largely in excess, occurring in irregular rounded grains, that look as though they might be primary. It is slightly pleochroic, changing from light yellowish-green to colorless. The feldspars are partly kaolinized but are probably all plagioclase. A little quartz and a few small grains of ilmenite, partly altered to leucoxene, make up the remaining minerals present.

Pegmatite Belt.

GENERAL DESCRIPTION.

The pegmatite belt can be traced across the area mapped, in a northeast and southwest direction, from Hadensville in Goochland County, to Cumberland, near the southern boundary—a distance of over 30 miles—and it extends for an unknown distance beyond the limits of the map. In width the belt varies up to nearly three miles, and perhaps more, for lack of exposure makes it difficult to locate the exact boundaries except in a few localities.

While pegmatite is the dominant rock in this belt, there is also much interleaved granite, especially along the eastern side. North of James River, where the area was mapped in detail, the northwest contact of the pegmatite with the granite is sharply defined, but the other boundary is less definite, for the pegmatite apparently fingers out into the granite; and in many places the two rocks are so closely associated that it would be impossible to map them as separate units. In most of the specimens of granite obtained from the central portion of the pegmatite area, and examined microscopically, the potash feldspars are dominant over the soda-lime feldspars. Hornblende schists are practically absent; no outcrops were seen, and the few pieces of float found were near the border portions.

The pegmatite area is one of low relief and there are few prominent outcrops. It seems to be less resistant to erosion than the granite, and this probably explains the location of Little Byrd Creek, which, throughout almost its entire length, is confined to the pegmatite belt.

DETAILED DESCRIPTIONS.

James River section.—The best rock exposures found in the pegmatite belt occur along the steep hills and bluffs that border the lowlands on the north side of James River. The railroad station at Island is near the center of the belt, which is here about 3 miles wide. The western boundary crosses the river midway between Columbia and Island, and is sharply defined; but the eastern boundary, which crosses the river near Byrd Creek, is less definite, for the pegmatite is more or less interleaved with biotite granite and the exposures are rather poor.

Near the western boundary of the pegmatite belt, 1¼ miles northwest of Island, there are outcrops of coarsely crystalline pegmatite (Spec. 12-A) composed of pink orthoclase feldspar, quartz, and a little muscovite. The

feldspar, which is dominant, occurs in irregular individuals ranging up to 2 or 3 inches in diameter. The rock is slightly gneissic in structure, the strike of the schistosity being northeast and southwest and the dip nearly vertical.

In places the coarse pegmatite is interleaved with a fine-grained pegmatite or granite (Spec. 12), similar in composition, and highly schistose. Examined under the microscope it is seen to be granitic in texture with occasional fine micrographic intergrowths of quartz and feldspar. Microcline is the dominant mineral, orthoclase being also present, while quartz and acid plagioclase feldspars occur in lesser quantities. The feldspars frequently show perthitic intergrowths and are partly kaolinized; the quartz contains irregular fluid inclusions, which occasionally hold moving bubbles; and both minerals have been more or less fractured and show some optical distortion. The muscovite is partly if not entirely secondary after feldspar. Magnetite, ilmenite partly altered to leucoxene, and titanite make up the minor accessory minerals.

A coarse-grained, gneissic pegmatite, which outcrops half a mile west of Island, contains numerous red garnets, 1 to 2 mm. in diameter; otherwise it is similar to the rock previously described. In the vicinity of Island there is much biotite granite intermixed with the pegmatite.

Little Byrd Creek.—For several hundred yards east of Little Byrd Creek, and about 2½ miles northeast of Island, the road to Fife is crossed by alternating bands of pegmatite and granite, which vary in width from an inch up to several feet. The average strike is N. 45° E. The pegmatite (Spec. 71) is composed of pink potash feldspar, in individuals ranging up to 3 inches in diameter, quartz, a little muscovite, and a few dark red garnets, some of which are over half an inch in diameter. In places a graphic intergrowth of quartz and feldspar may be distinguished. Farther east the bands are somewhat contorted.

Where the large branch crosses the road, half a mile west of Little Byrd Creek, a dark brown, fine-grained granite is exposed. It is about 50 yards wide and has a strike of N. 45° E. The rock (Spec. 70) is fine-grained, even-granular, except for occasional phenocrysts of potash feldspar about 0.5 cm. in diameter, and is only slightly schistose. Examined under the microscope it is seen to consist of potash feldspar (chiefly orthoclase), soda-lime feldspar, quartz, biotite, muscovite, a little light brown hornblende, a few scattered grains of magnetite or ilmenite, and occasional needle-like inclusions of rutile. The feldspar individuals, near their borders, frequently show granophyric intergrowths with quartz. The

quartz grains contain numerous fluid inclusions, some of which hold rapidly moving bubbles. Both quartz and feldspar show fracturing and optical distortion. The muscovite is partly secondary after feldspar but some of it is probably primary.

Lantana.—The contact between the pegmatite and granite crosses the road to Bula, 1⅛ miles southeast of Lantana. The outcrops are much weathered but in places graphic intergrowths of feldspar and quartz can be seen. The pegmatite weathers to a white soil which is readily distinguished from the gray, sandy soil of the granite and the dark red clay of the hornblende schist.

Bula.—On the east side of the pegmatite belt, in the vicinity of Bula, the boundary is not very definite, for the pegmatite splits up into dikes that are separated by areas of granite. One of these dikes is located about half a mile southeast of Bula, and can be traced in a northeast and southwest direction for a mile or more. This pegmatite (Spec. 77) contains a large amount of muscovite mica, and flakes 2 or 3 inches in diameter are sometimes found on the surface.

Shannon Hill.—The western boundary of the pegmatite belt crosses the Three Chop road about 2½ miles southeast of Shannon Hill. There are practically no outcrops along this ridge road, but an exposure of partly decomposed pegmatite was found in a recently opened ditch. The rock is a beautiful example of graphic pegmatite, being composed almost exclusively of feldspar and quartz, and shows little if any schistosity.

Dickey farm.—On the farm of G. S. Dickey, 2 miles southeast of Cremona, there are several pits that were sunk in prospecting for gold. Natural exposures are few in this vicinity, but the country rock is partly a dark granite similar to Spec. 70, described on page 60. In the pits a dark blue, close-textured, siliceous rock is exposed, which appears to have been formed by silicification of the country rock, for it contains fragments of the granite that are only partly replaced by silica. The rock is extensively brecciated and has been recemented by white vein quartz. There are numerous vugs lined with quartz crystals and many of the veinlets show crustification. The minerals sphalerite, pyrite, chalcopyrite, and galena, are present in small amounts and may be identified in places; and assays are reported to show traces of gold and silver. The ore minerals, at least in part, appear to be of later deposition than most of the quartz; in one specimen, sphalerite occurs filling a small cavity which is lined with quartz crystals.

Other localities.—Pegmatite is exposed at many places in Cumberland County along the strike of the pegmatite belt, but outcrops of fresh rock are rare, and all that were examined in detail show little variation from the occurrences described above. Pegmatite is exposed near Willis River, for a mile or two southwest of Flanagan Mills; it outcrops near Reynolds Creek, about 2 miles southeast of Trenton Mills, and again between Tally and Oak Forest; and there are numerous exposures in the vicinity of Cumberland, and near the southern boundary of the area mapped.

Columbia Area.

GENERAL DESCRIPTION.

The Columbia granite area is bounded on the northwest by the metamorphosed sedimentaries, chiefly pre-Cambrian in age, and on the southeast by the pegmatite belt; but much of the granite that occurs interleaved with the pegmatite and in the Elk Hill complex appears to be similar in mineral composition to the typical granite of the Columbia area, and probably has a common origin.

In the Columbian area there is very little rock present corresponding in mineral composition to a true granite, in which orthoclase is dominant over the plagioclase feldspar. Almost everywhere soda-lime feldspars are in excess, and near the border portion of the rock and close to many of the areas of hornblende schist, the potash feldspars are entirely absent. Therefore the rock may more properly be called a granodiorite or quartz-diorite. Muscovite is not common; biotite is usually plentiful in the dominant and more acid facies of the rock, but in the southern portion of the area it is largely replaced by hornblende.

Hornblende schists are of frequent occurrence in all portions of the area except in the north end of the tongue or embayment lying between Carysbrook and Wilmington; they become more plentiful near the contact with the old metamorphosed sedimentaries, where they commonly form a narrow belt separating the granite from the older rocks. In some places a gradation may be traced from granite into hornblende schist, but frequently the contact between the two is sharply defined. The areas of hornblende schist vary in size from a maximum of several square miles down to small masses, such as are usually called schlieren.

In passing northward from James River toward Carysbrook and Wilmington, there is a gradual but very noticeable change, both in the mineral composition and in the texture of the rock. While the exposures

are by no means continuous, outcrops are fairly plentiful along the bluffs of Rivanna River, and nowhere is there any evidence of sudden change such as would be expected if there were rocks present belonging to different periods of intrusion.

South of James River, soda-lime feldspars greatly predominate over the potash feldspars, which are frequently absent; most of the rock is hornblendic rather than biotitic; and the areas of hornblende schist are common. Passing northward toward Carysbrook the potash feldspars become more abundant though they are usually subordinate to the plagioclase; hornblende is rarely present in the granite, while biotite which is plentiful near the river becomes relatively scarce; and no areas of hornblende schist were found northwest of Rivanna Mills. The change is therefore one of decreasing basicity, and of decreasing percentages of the minerals that commonly crystallize out first.

In the vicinity of James River the granites are even-granular in texture but passing northward they become porphyritic and contain phenocrysts of feldspar. These phenocrysts are frequently bent and broken, the fractures as well as the interstitial spaces being filled with minerals of later crystallization; and this indicates that differential movements took place in the magma after crystallization had commenced and before the rock had completely solidified. The occurrence of masses of coarse-grained granite surrounded by rock of finer texture, such as may be seen in the quarry a mile northwest of Carysbrook (see description, pages 75-77), is probably due to the same causes.

The granite south of James River is highly schistose; the rocks exposed in the vicinity of Fork Union and Rivanna Mills are much less affected, while north of Carysbrook the granite is almost massive.

Pegmatite dikes are plentiful near Rivanna Mills, but were not noted elsewhere in the Columbia area. These pegmatites show little or no evidence of schistosity.

All of the facts outlined above lead to the same conclusions, namely, that the granite in the north end of the embayment between Carysbrook and Wilmington solidified later than the rock in the remainder of the area; that important differential movements took place while this later granite was in process of crystallizing; and that the magma from which the latter solidified was probably residual from the crystallization of the older rocks.

DETAILED DESCRIPTIONS.

Columbia.—The Cowherd quarries,[a] located on the north side of James River at Columbia, and lying partly in Goochland County and partly in Fluvanna County, furnish the best exposures of fresh granite that are to be found in the Columbia area. These quarries were first opened when the James River canal was in service, but in recent years little work has been carried on, and since 1900 all operations have been suspended.

The rock is of medium dark-gray color, fine-grained, even-granular, and very schistose, with fine, straight banding. The minerals distinguishable megascopically are white, glassy quartz and feldspar, black biotite, a few, light green grains of epidote, which are for the most part closely associated with the biotite, and occasional small pink garnets. Multiple twinning can be distinguished on some of the feldspars with the aid of a pocket lens.

The strike of the schistosity is N. 45° E. The vertical joints are widely spaced, intersecting the rock in three or more directions, and the joints parallel to the surface are spaced 2 to 3 feet apart in some of the deeper exposures. The granite is cut by numerous quartz veins which usually carry a little biotite. They vary from a fraction of an inch up to 2 feet in width, and run in all directions, though most of them are probably parallel to the schistosity. The fact that fractures frequently intersect the veins in directions coincident with the schistosity indicates that they were formed before the cessation of the period of deformation.[b] The presence of biotite and, occasionally, of a little muscovite and feldspar, are additional evidence of the early formations of the veinlets and of their probable magmatic origin.

Examined in thin section (Spec. 240) under the microscope the rock is seen to be composed of the following minerals, the order given being that of relative abundance—quartz, soda-lime feldspar (oligoclase), potash feldspars (chiefly microcline), biotite, muscovite, epidote, garnet, calcite, zircon, and apatite. Under low magnification the schistosity is distinct; most of the mica shows parallel orientation and the segregation of the quartz into bands is so pronounced that in places they resemble veinlets. This fact suggests that some of the quartz veinlets exposed in the quarry may have been formed by segregation through fractional crystallization during the solidification of the granite.

[a]Watson, Thomas L., Granites of the Southeastern Atlantic States, Bull. U. S. Geol. Survey, No. 426, 1910, pp. 112-113.

[b]Watson, Thomas L., Ibid., p. 113.

The quartz is present in large clear individuals that in places show a slightly wavy extinction; liquid- and gas-filled cavities are common, occurring partly in irregular shapes, and partly in small oval or rounded forms that are arranged in long rows or planes.

The soda-lime feldspar, which is dominant over the potash feldspars, shows rather coarse twinning after the albite law; the potash feldspar is nearly all microcline and there is only a little orthoclase present. Granophyric intergrowths of feldspar and quartz are fairly plentiful.

Biotite occurs in small dark green flakes showing strong absorption, and the white mica present is partly if not entirely secondary after feldspar. The epidote is in small, irregular light green to colorless grains, which are more plentiful wherever the biotite is abundant and are absent in areas containing little biotite.

Small pink garnets are scattered through the thin section; they are frequently fractured and broken, and seldom show good crystal form. The small amount of calcite present is evidently secondary. Numerous small idiomorphic crystals of zircon, and occasional apatite needles, are present as inclusions in the quartz and feldspar.

In mineral composition the rock is intermediate between granite and quartz-diorite. In the quantitative system of classification of igneous rocks it falls in class 1, order 3, rang 3, and subrang 4. A complete chemical analysis made from an average sample of the granite exposed in the quarry is given below.

Analysis of granite from Cowherd quarry, Columbia.

(Dr. Roger C. Wells, analyst.)

SiO_2	72.43
Al_2O_3	13.93
Fe_2O_3	0.90
FeO	2.45
MgO	0.58
CaO	3.38
Na_2O	3.20
K_2O	2.14
H_2O-	0.11
H_2O+	0.54
TiO_2	0.21
ZrO_2	.....
CO_2	0.09
P_2O_5	0.04
S	0.01
MnO	0.02
BaO	0.01
SrO	Trace
Li_2O	Trace
	100.04

About a quarter of a mile northwest of the quarries described above, and on the east side of the Stage Junction road as it leaves Columbia, a fresh surface of granite is exposed by recent blasting. The rock is cut by irregular veinlets of quartz some of which contain biotite mica; and there are also veinlets of coarsely crystalline calcite ranging up to 2 inches in width.

Megascopically the rock (Spec. 5) is similar to the granite described above, excepting that the gneissic banding is slightly more prominent. Under the microscope the chief difference is in the relative proportion of the feldspars, orthoclase and microcline being present in very subordinate amounts. White mica is practically absent and there is a little hornblende present, dark green to bright blue in color. Ilmenite, partly altered to leucoxene, occurs as a minor accessory constituent.

Passing northward along the Stage Junction road bands of hornblende schist begin to make their appearance at a distance of half a mile from Columbia. At first these bands or schlieren are only a few feet wide, but, as the contact with the sedimentaries is approached, they become larger and more plentiful until, within 400 or 500 yards of the contact, the granite completely disappears. There is also a change in the direction of the schistosity; near Columbia it has a strike of approximately N. 45° E., but near the sedimentaries the schistosity runs N. 15° W., and appears to be parallel to the contact. These areas of hornblendic rocks occur throughout most of the Columbia granite area, but they are much more plentiful in the vicinity of the borders.

About 1¼ miles east of Columbia there is a large rock exposure showing a gradation of the granite into hornblende schist. The schistosity varies from N. 20° to 40° E. The belt of hornblende schist is elongated parallel to the schistosity—the width being about 200 feet, and the length indeterminable because of the lack of sufficient exposures.

Specimen 6, taken more than 100 feet west of the belt of schist, is intermediate in character, but in the hand specimen is almost indistinguishable from the typical Columbia granite. The rock is dark gray in color, fine-grained, and shows a well-developed gneissic banding. It is composed essentially of quartz, feldspar, biotite, black hornblende, which is very difficult to distinguish megascopically from the biotite, small pink garnets, and a little epidote.

Examined under the microscope, soda-lime feldspar seems to be dominant over quartz, the potash feldspars are absent, and the hornblende is equal to or in excess of biotite. The feldspar frequently shows twinning

according to the pericline as well as the albite law; the quartz contains numerous fluid inclusions arranged in long lines or planes; and the hornblende is brown to dark green in color, and shows occasional idiomorphic outlines with perfect cleavage. Small, well-formed, pink garnets, a few grains of light green to colorless epidote, and, rarely, small idiomorphic crystals of zircon make up the minor accessory minerals.

Specimen 7 was taken from the outcrop about 30 feet northeast of the rock just described. It is finer grained than specimen 6, and contains more hornblende, much of which is concentrated in narrow streaks or schlieren. Under the microscope, plagioclase feldspar is seen to be dominant over quartz, and there is no potash feldspar or white mica present. The feldspars show twinning after the pericline as well as the albite law, and some of them contain peculiar inclusions of feldspar or quartz, which are present in alternate bands of the albite twinning. These inclusions are in the form of narrow parallel bands, which are oriented at an angle of 30° to the twinning planes, and they all extinguish simultaneously. The hornblende is strongly pleochroic in shades of dark green, blue, and greenish-brown. The biotite is light brown to green in color and is not nearly so plentiful as the hornblende. Garnet in fairly well formed crystals, irregular grains of epidote, ilmenite, and small inclusions of zircon make up the minor constituents.

About 110 feet east of the specimen just described, the rock (Spec. 8) contains flat, bladed crystals of black hornblende, ranging up to 1 cm. in length, embedded in a medium-grained ground-mass of feldspar and quartz. With increase of hornblende there is a corresponding decrease of biotite, and portions of the rock are almost free of mica. The garnets are likewise larger in this rock, some of them being nearly 0.5 cm. in diameter. The larger size of some of the minerals, especially the hornblende, may have been caused by a partial resolution before complete solidification had takn place, followed by continued crystal growth.

Microscopically, soda-lime feldspar is the dominant mineral and there is no potash feldspar or white mica present. Both albite and pericline twinning are common. Quartz is the second mineral in relative abundance and contains numerous irregular fluid-filled cavities. Dark green hornblende is the principal ferromagnesian mineral, only a little brown biotite being present. The remaining accessory minerals are garnet, in numerous well-formed crystals, epidote, ilmenite partly altered to leucoxene, pyrite partly altered to limonite, and small included grains of titanite and zircon.

Specimen 9, taken from a point 30 feet southeast of the rock last described, is a typical quartz-diorite schist. It is a dark gray, medium-

grained rock in which black hornblende, and white quartz, and feldspar are the only minerals distinguishable megascopically. Under the microscope plagioclase (probably andesine) is seen to be dominant, but dark green hornblende is almost as abundant as the feldspar. Quartz, a little epidote, and a few small, scattered grains of ilmenite make up the remaining constituents. Both quartz and feldspar show considerable optical distortion and some fracturing.

Specimen 10 was taken 80 feet farther northeast. Megascopically it is similar to specimen 9, but contains more hornblende and is darker colored, being almost black. Examined microscopically no feldspar could be distinguished. The minerals present in the order of their relative abundance are hornblende, quartz, epidote, chlorite, and a few scattered grains of ilmenite.

About 100 feet to the east there is an outcrop of greenish-gray, talcose schist, which probably represents an alteration product of the amphibolite schist described above. In thin section (Spec. 11) under the microscope, the rock is seen to consist of needle-like crystals of secondary hornblende, light green to almost colorless talc, a little chlorite, and numerous small grains of magnetite.

Near the large creek 2 miles southwest of Columbia there is much quartz lying loose on the surface and these pieces contain much muscovite, and occasionally miarolitic cavities lined with poorly formed crystals of quartz, feldspar, and muscovite. Some of the mica shows well-developed hexagonal shapes.

On the road to Lantana, hornblende schists are first encountered about half a mile northeast of Columbia, and, continuing northeastward, the occurrences increase in number and extent, until in the vicinity of the contact, little granite is to be found. The contacts between the areas of hornblende schist and the granite are commonly sharp and well defined, but in many places rocks occur that are intermediate in mineral composition.

Big Byrd Creek.—On the east side of Big Byrd Creek, near the contact between the granitic rocks and the altered sedimentaries, there is an outcrop of rock which is intermediate between the granite and the typical hornblende schists.

It is a dark gray, fine-grained gneiss (Spec. 29) composed essentially of feldspar, hornblende, quartz, and biotite. Examined microscopically the feldspar is seen to be all plagioclase; multiple twinning is frequently absent, and as the index of refraction is close to that of quartz, there is

difficulty in distinguishing between the two minerals. The hornblende crystals are strongly pleochroic, ragged in outline, and contain numerous inclusions of quartz, feldspar, and epidote. The biotite, which is partly altered to chlorite, is not plentiful. Ilmenite occurs in irregular grains scattered through the rock, and shows partial alteration to leucoxene.

Lantana.—A peculiar variety of the hornblende schist was found about 1¼ miles southeast of Lantana. The minerals recognizable megascopically are black hornblende and a little fine-grained, white feldspar. The hornblende crystals are frequently stained a deep red color, and the contrast between the black, red, and white gives the rock a very striking appearance in the hand specimen (93). Examined microscopically it is seen to consist of hornblende, basic plagioclase, epidote, quartz, magnetite partly altered to limonite, and a few small grains of rutile.

About 2½ miles northeast of Lantana the pegmatite belt approaches within less than 400 yards of the altered sedimentaries, and the intervening space is largely occupied by hornblende schists. At this point the biotite granite is absent, being replaced by a hornblende-bearing rock (Spec. 99), which closely resembles a granite in appearance, but contains no potash feldspar. It is a medium, dark gray, gneissic rock, composed of quartz, acid plagioclase, hornblende, and garnet, with lesser amounts of magnetite, zircon, and titanite. Some of the feldspar is unstriated and difficult to distinguish microscopically from quartz, which it resembles in refraction and birefringence. The hornblende is dark green to bluish-green in color, strongly pleochroic, and shows fairly good cleavage. Pink garnets are very plentiful, and the larger ones contain numerous inclusions of quartz and magnetite.

Passing northeast from the locality just described, the lack of exposures makes it difficult to trace the exact contact between the granite area and the metamorphosed sedimentaries; and this difficulty is increased by the uncertainty as to the igneous or sedimentary origin of some of the rocks in the immediate vicinity of the contact.

Granite is exposed in the branch near the private road, less than a mile northeast of the Young American mine. It is a light gray, fine-grained rock (Spec. 105), composed chiefly of quartz and feldspar, with minor amounts of biotite. Under the microscope the feldspar is seen to be plagioclase (probably andesine), but, as much of it is unstriated, it is distinguishable from quartz with difficulty. The rock contains a little sericite, ilmenite partly altered to leucoxene, and occasional small inclusions of rutile, titanite, and zircon.

Tabscott.—Granite and hornblende schist outcrop together near the branch half a mile northeast of the locality last described and about 1¾ miles south of Tabscott. The granite (Spec. 108) is a light gray, fine-grained rock, gneissic in structure, and composed for the most part of quartz, feldspar, and small flakes of light green chlorite. Examined microscopically the feldspars are seen to be chiefly acid plagioclase, with only a little orthoclase present; granophyric intergrowths with quartz are common; and in places the feldspars show alteration to sericite. Ilmenite occurs in small grains that usually show alteration to titanite or leucoxene. The alteration to titanite is more common and there are many grains of the latter scattered through the rock.

The hornblende schist (Spec. 109) is dark bluish-gray in color, and usually fine-grained. The hornblende, which is dominant, occurs in slender, prismatic crystals, that are dark green in thin sections, and frequently show idiomorphic outlines and perfect cleavage. Quartz and unstriated plagioclase feldspar (probably andesine) fill the interstices between the hornblendes. Ilmenite and rutile are prominent accessory constituents, occurring as included grains in all of the other minerals, though they are not so plentiful in the hornblende. There are also numerous grains of titanite present, probably secondary after the other titanium minerals, and small crystals of zircon occur as inclusions in the quartz.

A similar, but slightly coarser-grained, hornblende schist outcrops in the road 1½ miles southwest of Tabscott. The rock (Spec. 215) is composed of hornblende, quartz, unstriated plagioclase (oligoclase or andesine), a little epidote, and numerous grains of titanite, some of which contain small inclusions of rutile. In these schists the hornblende crystals have a strong tendency to lie with their columnar directions almost parallel, and it is this that gives the rock its schistosity. The strike of the schistosity is N. 51° E.

Payne farm.—On the Payne farm, 1½ miles southeast of Tabscott, there is a number of old pits or quarries from which the Indians obtained steatite. These openings are surrounded by pieces of broken bowls which were ruined in the process of making. Recently, sawed slabs of this rock have been used to line the fire boxes of boilers, at some of the mines in the vicinity, and it is said to have proved very satisfactory for the purpose.

The rock (Spec. 107) is greenish-gray in color and in places contains small crystals of magnetite and pyrite. Under the microscope it is seen to consist largely of talc and needle-like crystals of secondary hornblende. There are also a few fragments of unaltered hornblende which may be primary,

much chlorite, and a little magnetite or ilmenite, and titanite. The rock is evidently derived from a basic igneous rock, probably from the hornblende schists. A similar occurrence is described on page 68.

Some of the rock in this vicinity contains a greater percentage of hornblende than the specimen described above, and other pieces were found that consist exclusively of bright green cleavable chlorite.

Trent farm.—On the south side of James River, in the southern portion of the Columbia area, the rocks are apparently more basic in composition, potash feldspars are practically absent and hornblende is often more prominent than biotite. On the farm of S. W. Trent, 3 miles southwest of Hatcher, hornblende schist occurs in the vicinity of the contact. The rock is dark gray to black in color, with a highly lustrous fracture, due to the presence of much hornblende having approximately parallel orientation. The minerals present, in the order of their relative abundance, are prismatic hornblende, feldspar, quartz, and a little epidote. The feldspar is all plagioclase, corresponding to labradorite in extinction angle and index of refraction, and much of it is unstriated.

Passing northwest as far as Hatcher, hornblende is a prominent constituent in most of the rocks found; in places it is dominant over the other minerals, forming the typical hornblende schists, but elsewhere feldspar is dominant, and the rocks correspond to diorites and quartz-diorites in composition. On the whole hornblende appears to decrease in abundance with distance from the contact. The same statement holds true for the rocks that are exposed between Lawford and the contact.

Trenton Mills.—On the west side of Willis River, in the vicinity of Trenton Mills, there is a large area of hornblende schist, possibly 2 or 3 square miles in extent. The rock is medium-grained and highly schistose, the color varying from gray to black according to the amount of feldspar and quartz present. The darker varieties are composed almost exclusively of hornblende.

New Canton.—In some of the branches 3 or 4 miles south of New Canton a hornblende granite or quartz diorite is exposed, which contains a few large flakes of dark brown biotite and small pink garnets. A short distance east of the county road and 1¾ miles south of New Canton a light gray, gneissic rock (Spec. 300) is exposed which consists essentially of feldspar, quartz, biotite, and muscovite.

Examined under the microscope no potash feldspar could be identified. The plagioclase has an index of refraction slightly below quartz, approximately corresponding to oligoclase in composition, and frequently shows

twinning after the albite and pericline laws, but much of it is unstriated. The biotite is brown to green in color and the muscovite is partly if not entirely secondary in origin. A little chlorite and epidote are present, but other accessories are rare.

Stearnes.—Near the Chesapeake and Ohio Railroad, 2 miles northeast of Stearnes and 4 miles southwest of Columbia, the granite (Spec. 14) is light gray, fine-grained, and shows distinct gneissic banding. Occasional phenocrysts of feldspar showing Carlsbad twinning can be distinguished in the hand specimen. This is one of the few localities in the Columbia area where the rock is a true granite in mineral composition. The minerals present, in the order of their relative abundance, are potash feldspar (chiefly microcline), soda-lime feldspar (oligoclase), and quartz; a little biotite, muscovite, calcite, and epidote; and lesser amounts of garnet, titanite, ilmenite, leucoxene, and zircon.

Microcline showing beautiful crossed twinning is the dominant mineral and orthoclase seems to be practically absent. Oligoclase, which is the second mineral in relative abundance, shows occasional twinning after the pericline as well as the albite law, and microperthite is fairly plentiful.. Micrographic intergrowths with quartz are common. The biotite is dark green to brown in color and not very abundant; the flakes are usually oriented parallel to the schistosity of the rock. The white mica appears to be entirely secondary after feldspar, but there may be some primary muscovite present. It does not show the same uniformity of orientation that is exhibited by the biotite. Calcite is unusually abundant and is probably secondary after plagioclase. Epidote occurs in small grains, being more plentiful where the biotite is most abundant, and is undoubtedly secondary in origin. The garnets contain numerous small inclusions of quartz. Titanite is common and in places contains included grains of ilmenite, from which it may have been derived. The ilmenite grains occasionally show partial alteration to leucoxene.

For a mile northeast of Stearnes hornblende schist is exposed in the bluffs along the railroad. It is a fine-grained, dark bluish-gray rock, composed of small black prismatic crystals of hornblende, showing approximate parallel orientation, and white plagioclase and quartz. The contact with the granite on the northwest side of the schist is well exposed. It is sharply defined, without evidence of gradation, and has a strike of N. 45° E.

Near Stearnes the hornblende schist is cut by narrow bands of siliceous rock 2 to 3 inches in thickness. This rock (Spec. 16) is fine-grained,

light gray in color, and closely resembles a quartzite in texture and appearance. Small pink garnets and needles of dark green hornblende are present in places, and some of the rock contains much fine-grained magnetite. A thin section examined under the microscope contains irregular rounded grains of quartz, many idiomorphic crystals of magnetite, a few scattered prisms of dark green hornblende showing occasional crystal outlines, a little plagioclase feldspar, sericite, and small inclusions of titanite and zircon. The quartz contains numerous fluid inclusions.

Fork Union.—The contact between the granite and the metamorphosed, pre-Cambrian sedimentaries passes through the town of Fork Union. Granite is exposed in the road about half a mile southeast of the town. It is a medium-grained, light gray rock, containing flakes of biotite 2 to 3 mm. in diameter, and is much less schistose than the rocks previously described.

Examined in thin section (Spec. 50)[a] under the microscope, potash feldspar (chiefly microcline) appears to be dominant over soda-lime feldspar, but the rock is so badly altered that it is impossible to determine their relative proportions. Micrographic intergrowths with quartz are common. Both quartz and feldspar show fracturing and strain shadows. The biotite occurs in greenish-brown flakes showing strong absorption. The feldspars and biotite are extensively altered with the production of epidote, a little chlorite, and some sericite, as the principal secondary minerals. Reddish-brown prisms of tourmaline 1.5 mm. or more in length are occasionally present, and rutile needles are abundant especially in some of the biotite. Fluid inclusions are common in the quartz grains.

A similar granite, occurring at the Snead mine a mile north of Fork Union, is described on page 181.

Rivanna Mills.—On the farm of H. Williams, half a mile north of Rivanna Mills, granite was formerly quarried to furnish stone for the dam and canal locks. This rock is medium dark gray in color and porphyritic in texture, containing eyes of feldspar that range up to nearly 1 cm. in diameter. The minerals recognizable megascopically are feldspar, quartz, biotite, a little muscovite, and, rarely, small grains of pyrite. Some of the feldspar phenocrysts show fine multiple twinning. The schistosity is well developed, but is not nearly so pronounced as in the granites exposed in the section along James River.

[a] This thin section was made from a specimen collected by Dr. T. P. Maynard.

An average sample of partly decomposed granite, from an outcrop 100 yards east of Mr. Williams' house, upon assaying yielded 0.015 ounces of gold per ton (see pp. 220-221). The sample was taken after several inches of the partly decomposed rock had been removed in order to prevent contamination.

Dikes of pegmatite and aplite occur cutting the granite at several points on the Williams farm, and these rocks show very little if any evidence of schistosity. One of these dikes, located about 600 yards northeast of the house, is exposed in a prospect shaft 15 feet in depth. It has a strike of N. 15° E. and dips northwest at an angle of 45°. The pegmatite near the walls of the dike (see fig. 3) is fine-grained, and composed for the most part of feldspar and quartz, with only a little muscovite. The central portion of the dike consists chiefly of quartz carrying more or less feldspar and containing occasional coarse crystals of pyrite. Picked specimens of this quartz are said to have assayed nearly $3.00 gold per ton.

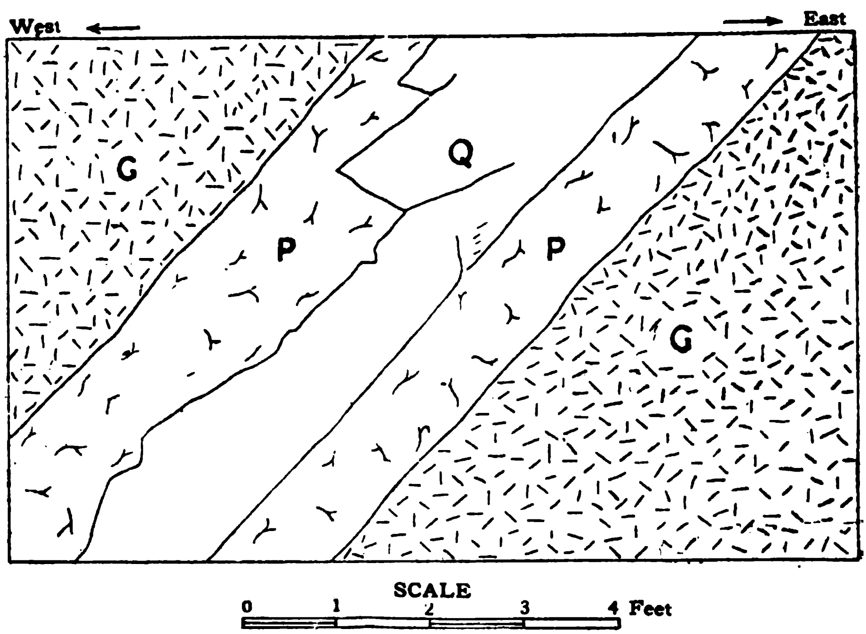

Fig. 3.—Vertical section showing pegmatite dike cutting granite near Rivanna Mills. *G*, granite; *P*, fine-grained pegmatite; *Q*, quartz with a little feldspar and pyrite.

South of Rivanna Mills and also in the road three-quarters of a mile to the east there are numerous exposures of hornblende schist, and in the latter locality they are occasionally cut by small pegmatite dikes.

Carysbrook bridge.—On the east side of Rivanna River, 150 yards below the road leading from Carysbrook to Wilmington, there is an exposure of granite (Spec. 61) containing feldspar phenocrysts ranging up to 1.5 cm. in diameter. The rock contains much less biotite than most of the granites previously described, and is only slightly schistose.

Examined under the microscope, acid plagioclase is seen to be dominant with only minor quantities of orthoclase present. The feldspars show twinning after the albite, Carlsbad, and pericline laws, and in places there are micrographic intergrowths with quartz. The larger individuals frequently show evidence of having been bent and broken prior to the complete solidification of the rock, for the fractures are filled with minerals of later crystallization. The feldspars have been extensively altered to epidote, which is present in irregular rounded grains and in granular aggregates. The quartz contains rutile needles, imperfect zircons, and numerous fluid inclusions some of which show moving bubbles. There is also a small amount of light brown biotite present, but it is largely altered to chlorite. Pyrite is of occasional occurrence in small, cubical crystals, which show more or less alteration to limonite.

A specimen (60) of the granite obtained about 20 yards above the Carysbrook bridge is typical of most of the rock in this vicinity. It is slightly schistose in structure, the feldspars are gray in color, and the biotite is not very plentiful.

In thin section under the miscroscope it is seen that soda-lime feldspars (probably oligoclase) are dominant over the potash feldspars (orthoclase with a little microcline). The larger feldspars are frequently bent, or ruptured and faulted, and in some cases the fractures are filled with minerals of later crystallization, indicating that there were probably differential movements in the magma after crystallization had commenced and before the rock had completely solidified. The feldspars show twinning according to the albite, Carlsbad, and pericline laws, and they are more or less altered with the production of sericite, kaolin, epidote, and a little calcite. Biotite is present in small light green flakes partly altered to chlorite. The quartz contains numerous fluid inclusions and occasionally moving bubbles. Tourmaline is of sparing occurrence in light brown crystals with ragged outline.

Carysbrook.—A quarry, opened in the granite to obtain rock for use in building the railroad, is located on the south side of Rivanna River, at

the Virginia Air Line railroad bridge, a mile northwest of Carysbrook. This quarry is within 100 yards of the contact between the granite and a chloritic slate which lies on the west.

The rock exposed in the quarry is exceedingly variable in appearance; there are irregular areas or blotches of coarse-grained granite, ranging up to a foot or more in diameter, which are surrounded by a ground-mass of finer material; and the entire rock-mass is cut by irregular fractures running in every conceivable direction. Differential movements have taken place along some of these fractures, resulting in the formation of slickensided surfaces and the production of a little light green chlorite.

The masses of coarse-grained granite are composed essentially of feldspar, quartz, and biotite, with a little pyrite in places. Some of the feldspars are 1 cm. in diameter, but the larger ones are frequently fractured and broken. They are white to light gray in color and occasionally show coarse multiple twinning. The biotite flakes, which range up to 0.5 cm. in diameter, have no regular orientation, and the rock shows little evidence of regular schistosity. In places the rock is cut by narrow veinlets, 1 to 2 mm. wide, which are largely composed of feldspar similar to that of the inclosing granite.

The fine-grained facies of the rock contains little or no biotite, consisting chiefly of feldspar and quartz; and as it has a uniform light gray color it is difficult to distinguish between the two minerals. A little calcite occurs in places along some of the fracture lines.

Some of the granite found in the quarry and at other localities in the vicinity contains feldspars that are pink instead of gray in color, but this difference is probably due to alteration with the production of some ferric oxide, as the pink and gray varieties of rock are apparently similar in other respects.

A thin section of the coarse-grained, gray granite was examined under the microscope.[a] The feldspars occur in large individuals, ranging up to 5 or 6 mm. in diameter, and are frequently fractured and faulted, while the fissures as well as the interstitial spaces are filled with minerals of later crystallization, chiefly quartz and feldspar. Soda-lime feldspar (oligoclase?) is probably dominant over the potash feldspars (orthoclase with less microcline), but the latter are abundant, and in places may equal the former. The plagioclase shows fine multiple twinning and is much altered by kaolinization, while calcite is also present as a secondary product.

[a]This thin section (Spec. 18) was made from a specimen collected by Dr. J. S. Grasty.

Liquid- and gas-filled cavities occur in some of the fresher feldspars and are abundant in the quartz. Quartz is not as plentiful as in the granites near the James River section. A few of the individual grains show optical distortion and fracturing, but most of them show no pressure effects. Biotite occurs in brownish-green flakes that are of later formation than most of the feldspar, and in places appears to have partly replaced potash feldspar. Chlorite is also present, probably as an alteration product of biotite. Pyrite is one of the minor accessories, occurring frequently in association with biotite—often along the cleavage planes. Ilmenite, partly altered to leucoxene, is present in small grains.

The thin section is crossed by a number of narrow, branching veinlets composed of fine-grained feldspar and quartz, with a little biotite and chlorite. These veinlets cut directly across the larger feldspars and other minerals.

A thin section of the pink granite, which was examined under the microscope, shows no essential difference from the rock described above. The feldspars have undergone greater kaolinization, the biotite is entirely altered to chlorite, and there is a little hornblende present, part if not all of which is secondary. A few ragged crystals of reddish-brown tourmaline, a little magnetite or ilmenite, and scattered grains of titanite are among the minor constituents. The rock is cut by narrow, branching fractures filled with dark green chlorite.

Granite similar to that exposed in the quarry extends southward beyond Carysbrook, and in the railroad cut half a mile south of the station, Ordovician sediments may be seen lying upon the eroded surface of the granite. Most of the rock is badly decomposed, but all fresh specimens seen were nearly massive in texture. The granite in this vicinity is essentially the same as the rock exposed at Carysbrook bridge (see description of Spec. 60, p. 75) excepting that the latter is markedly schistose.

Gold Hill Granite Area.

GENERAL DESCRIPTION.

The Gold Hill granite area lies between Kent's Store and Tabscott, in the northeastern portion of the region mapped. A general description of the area is given under the discussion of the country rock in the vicinity of the Gold Hill vein system (see pp. 176-177), and therefore will not be repeated here.

DETAILED DESCRIPTIONS.

McGloam mine.—The granite (Specs. 161 and 166) exposed on the dumps at the McGloam mine is typical of much of the rock in the Gold Hill area. It is light gray, fine-grained, even-granular, and the minerals distinguishable megascopically are feldspar, quartz, small flakes of dark green chlorite, a little sericite, numerous cubes of pyrite, and occasional grains of magnetite.

Examined under the microscope the rock is seen to vary from granitic to granophyric in texture. The feldspar is probably chiefly acid plagioclase, but twinning can seldom be distinguished. Orthoclase is also present and fine intergrowths of feldspar and quartz are plentiful. A little biotite occurs in the rock, but most of it seems to have been altered to chlorite. Sericite and calcite are fairly abundant as secondary minerals, probably derived from feldspars. The minor accessories include pyrite, magnetite, zircon, leucoxene, apatite, and rutile needles. Fluid inclusions are common in some of the quartz grains.

This rock, which is fairly representative of the granite in the Gold Hill area, differs from the granites previously described in being finer-grained, with a greater development of micrographic intergrowths of quartz and feldspar, and in having no schistosity. It contains less biotite and a relatively larger proportion of some of the minor accessories, such as pyrite and magnetite.

Pieces of hornblende schist are present on the dump of the incline shaft, but the schistosity is not so well developed as in most of the hornblende schists of the district. The rock (Spec. 167) is dark green in color and rather coarsely crystalline, containing bladed crystals of hornblende that range up to 1 cm. in length. The other minerals distinguishable megascopically are white feldspar and quartz, a little chlorite, and numerous small grains of magnetite and pyrite. Under the microscope it is seen that the hornblende is irregular in outline and contains numerous inclusions of quartz and feldspar, and in places there are graphic intergrowths of quartz and hornblende. The feldspar is unstriated plagioclase, probably albite. A little chlorite is present as an alteration product of hornblende, and rutile needles occur in some of the quartz grains.

Another variety of rock (Spec. 165) present on the dump is a chlorite schist containing scattered cubes of pyrite 2 to 5 mm. square, and octahedrons of magnetite ranging up to 2 mm. in diameter. Examined under the microscope, the chlorite is seen to be secondary from hornblende, of which many unaltered fragments remain. Aside from the alteration of

hornblende to chlorite, the rock is essentially the same as the hornblende schist described above.

Big Byrd Creek.—On the road, a quarter of a mile north of Big Byrd Creek and 1¼ miles southeast of Kent's Store, there is an outcrop of greenish-gray granite (Spec. 82), which is slightly coarser-grained than most of the rock in the Gold Hill area. Some of the feldspars are 2 or 3 mm. in diameter, and multiple twinning can occasionally be distinguished with the naked eye. Other minerals which may be identified in the hand specimens are quartz, chlorite, magnetite, garnet, and pyrite.

Under the microscope the rock is seen to be composed almost entirely of micrographic intergrowths of feldspar and quartz, the feldspar consisting of orthoclase, acid plagioclase, and microcline in the order named. Feldspar phenocrysts, 3 mm. in length, are scattered through the rock, and in their border portions are intergrown with quartz. Small grains of magnetite and of ilmenite partly altered to leucoxene are present. There is only a little mica—biotite and sericite—in the rock, but chlorite probably derived from biotite is common. Garnets, light pink in color, are of frequent occurrence; they usually contain numerous inclusions of quartz, and in places show micrographic intergrowths. Small zircons are plentiful as inclusions in the larger crystals of quartz.

About 100 yards north of the rock just described there are outcrops of hornblende schist, and the rock with which it is in contact is intermediate in mineral composition between the typical granite of the Gold Hill area and the hornblende schist.

A specimen (83) of this rock is white to light gray in color, fine-grained, and contains small prisms of dark green hornblende in a white ground-mass. There may also be distinguished a few small phenocrysts of feldspar, quartz, a little pyrite, small grains of magnetite, and occasional pink garnets. Under the microscope, the feldspar phenocrysts, ranging up to 2 mm. in length, are seen to be acid plagioclase; they are very irregular in outline, are often broken, and have a corroded appearance. The ground-mass, consisting chiefly of quartz and feldspar, frequently shows micrographic intergrowths. The hornblende shows idiomorphic outlines, is dark-colored, and strongly pleochroic. A little chlorite is present, probably as an alteration product of the hornblende. Ilmenite partly altered to leucoxene and minute inclusions of zircon make up the remaining accessories.

About half a mile south of Big Byrd Creek and 1½ miles southeast of Kent's Store there are outcrops of chlorite schist in the road. The

schist (Specs. 80, 81, and 160) is clearly derived from a hornblende-bearing rock, and under the microscope fragments of unaltered hornblende can be identified. The rock which has undergone the least alteration shows the least schistosity. Small grains of pink rutile are scattered through the rock and can be easily recognized with the naked eye.

Examined microscopically the rock is seen to consist largely of chlorite and needles of secondary hornblende. Unstriated plagioclase feldspar, quartz, and unaltered fragments of primary hornblende are also present, together with numerous small grains of rutile and titanite, and a few inclusions of zircon. The titanite is partly if not entirely secondary after rutile and some of the larger masses contain nuclei of the unaltered mineral.

Hughes farm.—On the Hughes farm, half a mile northwest of the Tellurium mine, numerous pieces of breccia are found on the surface. The rock (Spec. 207) consists of angular and subangular fragments of quartz, feldspar, and fine-grained garnets, which have been more or less silicified and recemented by silica. Small cavities, lined with quartz crystals are occasionally present, and the secondary silica contains a little pyrite. The texture of much of the cementing silica, when it is examined megascopically, suggests that it was originally deposited as calcedony and subsequently altered to quartz. The fragments of country rock are largely replaced by silica.

The distribution of this rock in a northwest and southeast line, a quarter of a mile or more in length, suggests that the breccia was formed by faulting, and that the cementing silica was deposited by solutions circulating along the fracture.

Rosney Granite Area.

There is a considerable area of granite in the vicinity of Rosney, the terminus of the Buckingham Branch of the Chesapeake and Ohio Railway, but because of the lack of outcrops it is not possible to determine its precise extent. On the west it is in contact with quartz-sericite schists and on the east similar schists intervene between the Rosney area and the granite of the Columbia area. It is not improbable, however, that the two areas are connected beneath the sediments of the Farmville Triassic area, which lies a short distance to the southeast.

The granite is fine-grained, very schistose, and varies in color from light to dark gray. A specimen (383) from an outcrop in the road about three-quarters of a mile northwest of Rosney, contains both biotite and hornblende, the two minerals being distinguishable from each other with

difficulty in the hand specimen. In a thin section, which was examined under the microscope, the feldspar was all plagioclase (oligoclase), and no potash feldspar could be identified. Twinning after the albite law is abundant and occasionally a little twinning after the pericline law may be seen. The hornblende is dark green in color and frequently shows idiomorphic boundaries; the biotite varies from brown to green and is strongly pleochroic. Both minerals show alteration to epidote, but no chlorite was identified. Many of the quartz and feldspar individuals are fractured and show optical distortion. Ilmenite, largely altered to leucoxene and limonite, and idiomorphic crystals of zircon make up the minor accessories.

Between the rock just described and the contact, about half a mile northwest, there are no outcrops, but the residual decay indicates the presence of several bands of hornblende schist. In the road half a mile southwest of Rosney a fine-grained hornblende schist is exposed. It is a dark gray, even-granular rock composed for the most part of feldspar, hornblende, quartz, and a little biotite, with occasional small pink garnets.

On the north side of Whispering Creek, 2 miles south of Rosney, several pieces of porphyry were found, which probably belong to a dike, as the country rock in this vicinity is chiefly quartz-sericite schist. The rock is only slightly schistose and is therefore probably of later origin than the granite near Rosney, but it is not improbable that there is some genetic relation between the two occurrences.

The rock (Spec. 388) contains numerous light gray, rounded phenocrysts of feldspar, 5 to 6 mm. in diameter, which are surrounded by a ground-mass of fine-grained hornblende, feldspar, and quartz. Multiple twinning can be distinguished in places with a pocket lens, but most of the feldspars have a rough fracture because of the presence of microscopic inclusions. On weathering the rock gives a deeply pitted surface due to the early decomposition and removal of the feldspar phenocrysts.

Under the microscope the large feldspars are seen to be micropoikilitic in texture, being full of inclusions of quartz and hornblende that range in size up to 0.2 mm. in diameter; they have indefinite boundaries that grade into the surrounding ground-mass; and the extinction angles and index of refraction indicate a composition near labradorite. The hornblende is light green to nearly colorless and contains occasional inclusions of quartz. The quartz grains contain numerous fluid inclusions, and irregular rounded grains of titanite are plentiful, some of them containing nucleal fragments of light yellowish rutile.

About a mile west of Rosney and not far from the contact, there is a large amount of tourmaline present on the surface. Most of it occurs in long black prisms imbedded in vein quartz, but large masses were seen that consisted almost exclusively of small interlaced needles of tourmaline.

Granite at Greeley Mine.

Granite occurs in one of the openings of the Greeley mine, but there are no surface exposures and the occurrence is probably limited in its areal extent. The rock is described in detail on pages 206-207. The appearance of the rock, and the presence of much calcite and coarsely crystalline muscovite, suggests that extensively pneumatolitic action accompanied or followed the intrusion of the granite.

Porphyries.

DISTRIBUTION AND GENERAL DESCRIPTION.

In the district lying between the Gold Hill granite area and the Wilmington embayment of the Columbia area, there are a number of outcrops of feldspar porphyry. Lack of sufficient exposures makes it impossible to determine the size and character of these bodies, but most of them are limited in extent and should probably be classified as dikes. The other rocks occurring in this district are chiefly chlorite schists, hornblende schists, quartz-sericite schists, and quartzites, all of which are intensely metamorphosed.

The porphyries contain phenocrysts of feldspar ranging up to 2 mm. in length, and occasionally small eyes of quartz embedded in a fine-grained ground-mass composed essentially of feldspar, quartz, and usually a little hornblende, which may be more or less altered to chlorite and epidote. They vary considerably in composition, particularly in the amount of ferromagnesian mineral present. The phenocrysts are frequently fractured and the fragments separated, indicating that important differential movements took place during the crystallization of the rock.

The composition of the porphyries, their texture, and their distribution relative to the larger granite areas, are all indicative of their close genetic relationship to the granite and point toward an approximate contemporaneity of origin. Some of them are closely similar to the granite in the Gold Hill area.

DETAILS OF OCCURRENCES.

In the road 1½ miles northeast of Wilmington there is an outcrop of porphyry. It is a light greenish-gray rock (Spec. 63), fine-grained, and

slightly schistose. A few phenocrysts of feldspar, 1 mm. in length, and small flakes of light green chlorite are the only minerals distinguishable megascopically.

Under the microscope the phenocrysts are seen to be well-formed crystals of acid plagioclase, nearly 1 mm. in length, which show twinning after the Carlsbad and albite laws. They are occasionally broken and the fragments separated by minerals of later crystallization. The ground-mass is fine-grained, even-granular, and consists of feldspar, quartz, chlorite, small needles of hornblende, a few flakes of biotite, calcite, epidote, and small inclusions of zircon, titanite, apatite, and rutile.

Another outcrop occurs half a mile farther east where the rock (Spec. 66) is essentially the same. The phenocrysts are slightly larger, ranging up to 1.5 mm. in length, there is a small amount of magnetite present, and alteration has been carried a little farther, so that epidote is more plentiful, occurring in granular aggregates with quartz and a little chlorite.

On the southwest side of Big Byrd Creek, 2½ miles southeast of Wilmington, there is an outcrop of schistose porphyry. The rock (Spec. 68) is light gray with dark blotches due to areas of fine-grained biotite, and contains lenticular eyes of quartz, 4 mm. in length. A few feldspars, crystals of pyrite, red garnets, and a little fine-grained magnetite may also be distinguished in the hand specimen.

Under the microscope phenocrysts of acid plagioclase, over 2 mm. in length, can be identified; and many of them are broken and split apart along cleavage planes, the fractures being filled with the minerals of the ground-mass. The lenticular eyes of clear, granular quartz contain fluid-filled cavities and numerous inclusions of idiomorphic zircon and rutile needles. The ground-mass is fine-grained and consists of feldspar, quartz, flakes of brown biotite partly altered to chlorite, and a little pyrite, magnetite, titanite, and zircon.

In a branch on Mr. Williams' farm, 1¼ miles northeast of Rivanna Mills, a rock (Spec. 54) is exposed which is light gray, fine-grained and only slightly schistose. Small pink garnets, pyrite, flakes of light green chlorite, and a little fine magnetite may be recognized with the naked eye. Examined microscopically the feldspar phenocrysts are seen to be smaller than in the rocks previously described, and they are much corroded; the ground-mass is coarser grained, but otherwise the same. The surrounding rock is probably granite, but there are no exposures in the immediate vicinity.

At the road corner, 2½ miles south of Kent's Store, there is an outcrop of fine-grained, bluish-gray rock (Spec. 128) containing small eyes

of quartz 0.5 to 2 mm. in diameter. Under the microscope no feldspar phenocrysts could be identified; the quartz eyes contain rutile needles and well-formed zircons; and the ground-mass is composed essentially of feldspar, quartz, much hornblende in slender green prisms, and a large amount of fine-grained magnetite. A little zircon, titanite, and apatite are present as minor accessories. A similar rock found 50 yards east contains no eyes of quartz.

A rock (Spec. 62), having a ground-mass similar to the one just described, was obtained from a well near the road 3 miles northeast of Stage Junction. Instead of having eyes of quartz there are a few imperfect phenocrysts of feldspar less than 0.5 mm. in length.

A quartz porphyry, differing in texture and mineral composition from the rocks described above, occurs at the Morton mine, half a mile west of Johnson, Buckingham County. A microscopic description is given on pages 197-198.

CAMBRIAN OR POST-CAMBRIAN.

Diorite Dikes.

DISTRIBUTION AND GENERAL CHARACTER.

Dikes of altered diorite occur at several places in the area mapped, but there are a few good exposures, and the rock is of little importance as an areal formation. All occurrences that were observed are practically identical in appearance and mineral composition. The rocks were originally composed essentially of hornblende and plagioclase feldspar, but the latter mineral is now almost completely altered to a fine-grained aggregate of zoisite, epidote, and other secondary products.

AGE.

Since these rocks show little or no evidence of dynamic metamorphism, they must be younger than the pre-Cambrian rocks into which they have been intruded; and the fact that some of them are very slightly schistose indicates that they solidified before the close of the crustal movements which deformed the Ordovician rocks. For these reasons the diorite dikes are believed to be Cambrian or possibly Ordovician in age, but they may be younger.

DETAILS OF OCCURRENCES.

Palmyra.—A dike of partly decomposed diorite outcrops in the road near the northwest corner of the Courthouse yard at Palmyra, but the size of the dike could not be determined. The rock is composed essentially

of partly altered feldspar and dark green hornblende, and shows marked schistosity in the hand specimen. Under the microscope the feldspars are seen to be almost entirely altered to saussuritic aggregates of epidote, zoisite, and other secondary minerals, but in places a few residual fragments of basic plagioclase can be identified. The hornblendes are ragged in outline and show partial alteration to chlorite.

Long Island Creek.—The county road from Palmyra to Wilmington crosses a dike of weathered diorite about 100 yards east of Long Island Creek. The dike appears to be 100 yards or more in width, but could not be traced for any distance because of the lack of exposures. The strike is probably northeast and southwest. The rock is similar in appearance and composition to that described above, excepting that the percentage of hornblende present is slightly greater and the schistosity is scarcely noticeable.

Benton mine.—Pieces of weathered diorite were found on a rock pile in the vicinity of the shaft at the Benton mine. The rock (Spec. 221) is massive, even-granular, and shows no evidence of schistosity. It consists of green hornblende in crystals 1 to 2 mm. in diameter, which are uniformly distributed through a fine-grained, white ground-mass resulting from the alteration of feldspar. Under the microscope the feldspars are seen to be almost completely altered to secondary minerals, chiefly zoisite and epidote. The hornblende shows partial alteration to chlorite, and a little quartz, probably secondary, may also be distinguished.

Bowles mine.—On the Bowles tract, about 1¼ miles west of Tabscott, pieces of diorite float were found on the surface, but no outcrops could be discovered in place. The rock is similar in every way to that which occurs at the Benton mine.

TRIASSIC.

Diabase Dikes.

DISTRIBUTION AND GENERAL CHARACTER.

Diabase dikes, or trap rock as they are commonly called, are of occasional occurrence in all portions of the area mapped. They are in no wise different from the other dikes belonging to the same great series, which are found intersecting the older rocks all along the Atlantic slope from Nova Scotia to Alabama. These dikes are especially abundant in some of the Triassic areas, and cut all formations excepting the Cretaceous and later sediments of the Coastal Plain.

In the area covered by the present report the diabase dikes vary in width from a few inches to 200 or 300 feet, and at least one of them can be traced

for a distance of over a mile, its course being marked by occasional outcrops, and the black weather-beaten bowlders, which are locally called "nigger-heads." The dikes are usually approximately parallel to the strike of the enclosing rocks, and are nearly vertical.

The diabases are dark brown to black in color, and vary from medium fine-grained to aphanitic in texture. They are composed essentially of lime-soda feldspar, augite, and magnetite, while olivine is present in some and absent in others. These rocks are exceedingly hard and tough, and on account of this fact together with their good cementing qualities, they make excellent material for macadamizing roads.

DETAILS OF OCCURRENCES.

Columbia.—One of the largest and most persistent dikes in the district is exposed in the county road, a mile northeast of Columbia, where it is possibly 100 yards wide. It has a strike of approximately N. 15° E., and can be traced in a southwest direction as far as the river. The large outcrop of diabase half a mile east of Stage Junction lies in the same line of strike and may be a continuation of this dike, but lack of exposures makes it impossible to trace it on the surface.

The rock (Spec. 46) is dark brown, and rather coarse-grained, showing a marked ophitic texture even in the hand specimen. The feldspars range up to 8 mm. in length, and show polysynthetic twinning to the naked eye. Examined under the microscope the rock is seen to be composed of plagioclase, augite, magnetite, pyrite, and occasional flakes of biotite. The augite is mostly colorless in thin sections, but in places is finely twinned with a light green variety. Magnetite and pyrite are both plentiful in small irregular grains The biotite is dark brown, strongly pleochroic, and shows partial alteration to chlorite. No olivine was identified.

Grannison mine.—A dike of olivine diabase outcrops near the old mill at the Grannison mine, three-quarters of a mile south-southwest of Pryors Crossroads. It has a strike of approximately N. 25° W., but the width and length could not be determined. The rock is coarse-grained and the ophitic texture easily distinguishable to the naked eye. Examined under the microscope (Spec. 97) it is seen to consist of lime-soda feldspars, augite, much olivine, a few grains of magnetite, less pyrite, and a little carbonate (probably calcite). The feldspars occasionally show pericline as well as albite twinning, and zonal extinction is common. The carbonate is probably derived from the alteration of feldspars.

Pemberton.—A mile west of Pemberton, a diabase dike is exposed on either side of the narrow neck of land formed by the sharp bend in the river. Where well exposed the dike is only 5 or 6 feet wide, and while approximately vertical is very irregular in its dip. The strike is nearly north and south. The rock (Spec. 24) is medium-grained, even-granular, and dark gray in color. Under the microscope it shows the typical ophitic texture, and is composed of plagioclase, augite, and small idiomorphic grains of magnetite partly altered to limonite. The rock cut by the dike is a fine-grained, light gray granite-gneiss.

Dillwyn.—A dike of olivine diabase outcrops in the town of Dillwyn (see map, p. 185), and a similar dike, which is described on page 187, is found near the London and Virginia mine, three-quarters of a mile north of Dillwyn. The rock is dark brown in color, medium coarse-grained, and is composed of plagioclase, augite, olivine, and magnetite. The olivine shows extensive alteration to sepentine.

Other localities.—Several dikes of weathered diabase are exposed in the bluffs on the south side of James River near New Canton, and similar dikes were observed cutting the Ordovician slates. Diabase dikes at the Bondurant and McKenna mines are described on pages 195 and 254, respectively. Other occurrences are too numerous to mention in detail, and none of them differs in any material way from those already described.

CHAPTER III.

PHYSIOGRAPHY.

INTRODUCTION.

Virginia is naturally divided into three major provinces: (1) the flat-lying Coastal Plain which extends from the continental shelf, now 30 to 50 miles east of the present shore-line, to the fall-line at the head of tidewater; (2) the Piedmont Plateau extending from the Coastal Plain on the east to the foot of the Blue Ridge; and (3) the Appalachian Mountains province which embraces the western or mountain portions of the State. (See fig. 1.)

The Piedmont Plateau lying between the Coastal Plain and the Appalachian Mountains has a width of about 40 miles in the northern portion along Potomac River, but going south it widens until at the Virginia-Carolina state-line it extends for nearly 175 miles. The district under consideration is located in the center of the Piedmont Plateau province where the width is about 75 miles. The district presents the general surface features characteristic of the Piedmont Plateau throughout Virginia; low relief, a network of streams which afford perfect drainage to the region but which are heavily loaded with sediment, and a deep mantle of residual decay which covers most of the country except where the larger streams have cut down their valleys into the underlying rock.

RELIEF.

The elevations indicated on the map of the area (see Pl. I, in pocket at back of book), by means of contour lines, are approximately correct, and serve to portray the principal physiographic features. The topography, as shown on this map, is adopted from the topographic sheets of the United States Geological Survey, with corrections by the writer.

The most characteristic feature of the relief is the absence, over the entire area, of any notable elevations, with the single exception of Willis Mountain. This fact is forcibly impressed on the observer by the bird's-eye view of the country obtained from the top of Willis Mountain. Looking from this elevation, the country appears as a broad, flat plain, stretching from the foot of the mountain toward the north, east, and south as far as the eye can reach, while toward the west it is limited only by the foothills of the Blue Ridge.

In traveling any great distance across country, one soon finds that the surface instead of being perfectly level, is gently rolling, and consists, for the most part, of broad, flat-topped ridges and comparatively narrow valleys. If, however, one follows one of the main ridge roads, which have from the earliest days been the chief transportation routes of the country, the illusion of a vast level plain is maintained, for many of the ridges extend along distances with little variation in altitude. Thus, in traveling over the roads that lead from Cartersville to Cumberland, New Canton to Dillwyn and Buckingham, or from Stage Junction north by way of Wilmington, one may go for distances of 15 or 20 miles over an apparently level country.

Glancing at the map, it is seen that neighboring ridges have approximately the same elevations, but that in passing across the area from east to west the height of the elevations gradually increases; along the eastern border of the area the ridges are about 450 feet above sea level, while in the western portion they average from 550 to 600 feet in elevation. If it were possible to fill in all of the valleys level with the tops of the ridges, we would have a broad, flat plain sloping gently toward the ocean, and it is believed that this was the condition of the land surface at a former period, before the streams had cut their channels down to their present levels.

The rivers and larger creeks have cut their valleys deepest, about 250 feet below the present surface of the old peneplain, the smaller creeks somewhat less deeply, and their tributary branches only from 50 to 150 feet. All of the larger streams flow through narrow trench-like valleys with very limited bottom lands. In places where the rocks are especially resistant, as is the case with the quartzite beds at Bremo Bluff, the river lowlands are practically absent and the stream is bordered by almost vertical cliffs. (See Pl. III, and fig. 2.)

Willis Mountain, in the southwestern corner of the area, projects abruptly from the average level of the Piedmont Plateau and rises to a height of 1,159 feet above sea level. It is a prominent feature of the landscape for miles around, and is the most noticeable elevation found in the State, east of the outlying ranges of the Blue Ridge. (See figs. 4 and 5.) Topographically, it is a narrow ridge extending about two miles in a north and south direction, and the crest of the ridge is formed by a narrow wall of rocks, perhaps 100 feet high, which is so nearly vertical that it can be scaled only in places and with difficulty. (See Pl. IV, fig. 1, and Pl. VI, fig. 2.) The dip of the strata is slightly toward the west, and the

large fragments which have fallen along the eastern base have rendered this the easiest direction of ascent. From the foot of this wall-like precipice the mountain slopes steeply down to its base. The rocky ridge

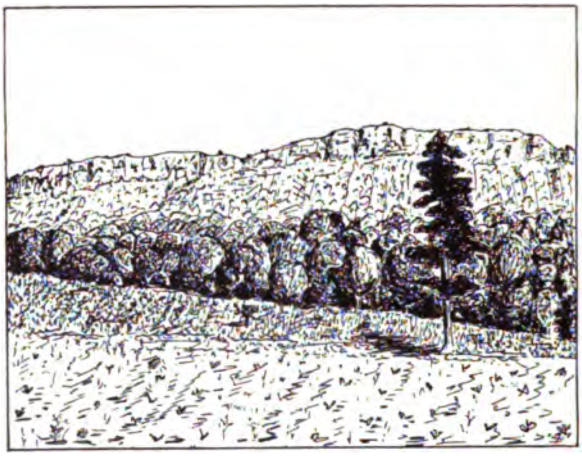

Fig. 4.—North end of Willis Mountain from the west.

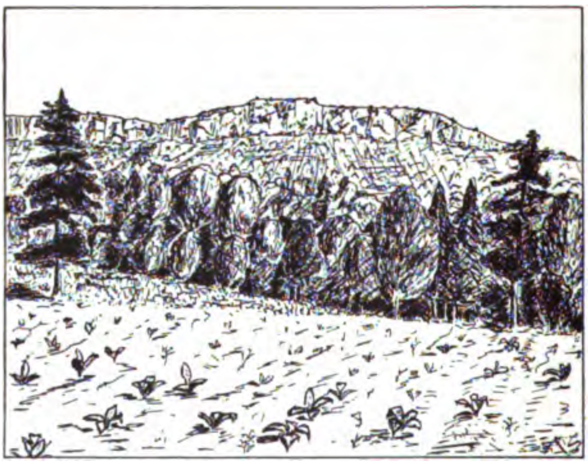

Fig. 5.—South end of Willis Mountain from the west.

forming the crest of the mountain is notched in several places, so that a number of distinct summits occur. The deepest of these notches is near the south end of the mountain, and the southern knob which it separates from the main ridge is locally known as Round Mountain. Willis

Mountain owes its origin to the resistant nature of the cyanite schist which outcrops along its crest, and which has offered greater resistance to erosion than any other rock in the region.

DRAINAGE.

The great master-stream of the area, James River, flows in a general southeasterly direction and cuts directly across the strike of the upturned edges of the rock strata, maintaining its course without reference to variations in their hardness. With its headwaters rising among the ridges of the Alleghany Mountains, James River flows eastward, cutting its way through the Blue Ridge as well as all minor barriers that rise athwart its course, and finally empties into the Atlantic Ocean. This independence of the chief structural features of the country, together with its intrenched meandering curves, proves that the river developed its course on a broad, level plain, before the present ridges were formed. Such a river is called an antecedent stream.

The principal streams draining the area and entering James River from the north are Rivanna River and Byrd Creek (see map, Pl. I). Both of these flow southeasterly across the strike of the upturned rock strata and show deeply trenched winding valleys, indicating that they are also antecedent streams.

Slate and Willis rivers are the largest streams that cross the area and enter the James from the south. It should be noticed that both rivers, after flowing in a general northeasterly direction throughout most of their length, suddenly change their courses as they approach the James, and enter it from an easterly or even a northeasterly direction; and, moreover, their lower courses are extremely crooked, while their upper valleys are fairly straight. These two rivers were doubtless at one time superimposed streams similar to those on the other side of James River, but as their direction of flow was nearly parallel to the strike of the rock strata, their courses were more easily modified and adjusted to the rock structure. This possibly explains the peculiarities in the courses of these streams and also the fact that their valleys are slightly broader and less steep than those of the corresponding streams on the opposite side of James River. Slate and Willis rivers may be considered as antecedent streams that have subsequently undergone modification and are now in partial adjustment to the structure.

Appomattox River, which crosses the southeast corner of the area, is clearly another antecedent stream similar to James River into which it flows some distance beyond the borders of the map.

It is thus seen that all the larger streams of the area are either antecedent streams or streams that are only in partial adjustment to the structure, and that they all show a strong tendency to flow in a southeasterly or easterly direction.

Most of the creeks and many of their branches are streams that owe their location to the underlying rock formations. These streams flow northeasterly or southwesterly parallel to the structure of the country, their direction of flow being controlled by their proximity to some larger antecedent stream. Hunt Creek, Phelps Creek, and Little Byrd Creek may be mentioned as good examples of structural control of drainage.

Hunt Creek has eroded its valley in the long, narrow area formed by the Arvonia slate belt, while the ridges on either side are composed of more resistant rocks—schistose quartzites and conglomerates.

Phelps Creek runs in a northeasterly direction through an area of highly metamorphosed schists and enters James River just east of New Canton. The ridge on the west side of the valley is composed of quartzite, while on the east stretches the granite area. A complementary creek flows southwest and enters James River directly opposite.

Little Byrd Creek flows southwest within the area of pegmatite, which is less resistant than the granite and hornblende schists on either side.

The hundreds of small tributary branches that drain into the larger streams flow in every conceivable direction, their courses being controlled partly by the geological structure, but chiefly by their proximity to one of the larger streams.

Most of the streams draining this area are rather swift and flow over occasional rapids, due to outcropping ledges of harder rock; their waters are usually muddy because of the large amount of fine material carried in suspension which has been derived from the residual soils that almost everywhere cover the underlying rocks.

It is interesting to note that in the case of some of the larger streams that are in structural adjustment, such as Little Byrd Creek on the north side of James River and Muddy Creek on the south, the principal tributary branches all enter from the west. This phenomenon is due to the eastern slope of the peneplain in which the streams have eroded their valleys.

The movement resulting in the tilting of this plain did not take place all at once, but undoubtedly extended over a long period of time, and was probably interrupted by periods of quiescence. Every increase in the eastern tilt of the land surface resulted in an increased velocity of the streams flowing in an easterly direction with a corresponding increase in

their powers of erosion. Streams flowing westward had their velocities diminished and if the amount of movement was sufficient the direction of flow may even have been reversed in some cases. The net result of this tilting was to cause the streams flowing in an easterly course to cut backward and lengthen their valleys faster than the streams flowing in the opposite direction. This process may have been accompanied by an easterly migration of the parent stream since the tilting would tend to induce greater erosion along the eastern bank. The bluffs appear to be somewhat more prominent on the east sides of these streams than on the west, but the difference is certainly not great. The chief result of any easterly displacement of the parent stream would be to lengthen the courses of its tributaries from the west and shorten those from the east, but it is not believed that this was an important factor in producing the unsymmetrical streams described above.

The rapid headward erosion of easterly flowing streams, caused by the tilting of the peneplain would bring about a condition favorable to stream capture; that is to say, the stream with greater velocity might cut its way back to some neighboring stream and divert the upper portion of its drainage. A close study of the region lying west of Little Byrd Creek indicates that this may have taken place, and that the headwaters of some of the branches north of Lantana, which now flow east into Little Byrd Creek, at one time drained southward into the large branch which enters Little Byrd Creek a mile above its mouth.

The principal facts in favor of this theory are as follows:

(1) The large branch which heads just east of Lantana and flows south into Little Byrd Creek has a valley that is almost as broad as that of Little Byrd Creek itself.

(2) The divide near the headwaters of this branch is low and in places swampy.

(3) Several of the tributary branches draining the area northeast of Lantana have a sharp bend in their courses which is approximately in alignment with the prolongation of the valley running south from Lantana.

(4) On some of the low ridges northeast of Lantana residual patches of placer gravel were formerly worked for gold. The position of this gravel is high above any of the neighboring streams, and these remnants are all that is left to indicate the location of an old stream bed which has long since been almost entirely removed by erosion.

PHYSIOGRAPHIC HISTORY.

It is known that this region passed through a long and varied history before the present physiographic features began to take form; it underwent

many changes in elevation, and for long periods of time it was depressed below sea level while the great series of sedimentary beds was being deposited. Later these beds were consolidated into hard rock and subjected to compressive forces which produced the complicated system of folding and faulting that is so noticeable wherever the rocks are well exposed. This process was accompanied and followed by intrusions of igneous rocks, and the area was elevated high above sea level.

As soon as the land appeared above water, the agents of the atmosphere began their work of decomposition and disintegration, and the newly formed streams began to wear away the land surface and transport the products of weathering to the ocean, where the material was redeposited to form new beds of sediments. Denudation was continued until the region was beveled across hard and soft formations alike, and the country reduced to a condition bordering on base-level. Such a surface is known as a peneplain.

The area has undoubtedly experienced several periods of peneplaination followed by renewed elevation of the land surface, but it is unlikely that the Piedmont section as a whole has been depressed below sea level since Ordovician time.

Following a period of base-leveling, the surface was warped enough to allow the Newark beds to be laid down in long, narrow trough-like basins, but, since that time, degradation has continued without interruption. The earliest great peneplain of which evidence remains extended far beyond the limits of this small area, and has been called the Kittatinny peneplain.[a] It probably dates from the Cretaceous period.

In many places in the Appalachian States peneplains of later date than the Kittatinny plain have been noted, and while it is possible that periods of subsequent base-leveling may have occurred in this section, they have not been identified, and it is improbable that more than one plain can be distinguished within the limits of this area.

It is impossible to accurately determine the thickness of the material removed during the ages in which this degradation of the land surface was going on, but certainly it is to be measured in thousands of feet. All of the changes outlined above took place gradually and covered a long period of time. While we can not even approximately estimate the length of this time as measured in years, it must have been very great even in comparison with the time which has since elapsed.

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[a] Willis, Bailey, The Northern Appalachians, Physiography of the United States, p. 189.

During the latter stages of peneplaination decomposition proceeded much faster than degradation; the products of rock decay accumulated more rapidly than they could be removed by the slow-moving streams, which had almost attained base-level, and a deep mantle of residual soil was gradually formed that completely covered the hard rocks below.

The appearance of the surface at that time was probably not very different from that of the lower Mississippi valley to-day. The land was flat and featureless and elevated but little above sea level. Willis Mountain was probably the only elevation within the limits of this area that stood above the monotonous level of the plain. The stubborn resistance to weathering offered by the rocks forming this mountain served to protect it from the complete reduction that had befallen the surrounding area, and left it standing as a solitary monadnock. The rivers meandered sluggishly over the land in wide curves, and there were no marked divides. The course of these streams is not known, but many conditions indicate that they possibly drained toward the west.

In this condition a very slight tilting of the land surface was sufficient to change the courses of the streams, or even cause them to flow in the opposite direction, and it was upon this surface that the new system of drainage represented by the present antecedent streams was inaugurated.

The new streams, assuming their positions while the rocks of varying hardness were still covered by a deep blanket of residual decay and alluvium, were not influenced by the structure of the underlying formations, and therefore ran slowly in winding curves closely coincident with those that they now possess. The establishment of the new drainage, however, was shortly followed by a progressive elevation of the land which quickened the streams, and they began the work of deepening their channels.

After cutting through the soft overlying material and exposing the fresh rock below, the larger streams continued the work of corrading their channels in the more resistant formations. As fast as renewed elevation of the land surface raised the hard beds athwart their course, the streams, confined to their channels and restrained from altering their courses by the deep valleys which they had excavated in the softer material, were forced to cut through hard and soft strata alike. It was in this way that the larger streams were superimposed upon the structure of the undecomposed underlying rocks.

The fact that the rivers have not been able to cut their channels in hard rocks as rapidly as in the softer formations, accounts for the rapids

that frequently occur. The rapids in James River at Bremo Bluff furnish a good example. Here the river flows across beds of hard quartzite which, dipping vertically, are interbedded with softer mica-garnet schists. Because of the greater resistance of the quartzite to erosive action, the river has not been able to cut its bed downward or to widen its channel in it as rapidly as in the softer rocks, and therefore the quartzite beds stand out as ledges from the bottom of the river and project from the sides of the valley in bold cliffs. (See fig. 2, and Pl. III.) At the bridge the valley is only 500 yards wide from bluff to bluff and there are practically no bottom lands, but at a distance of only one mile up or down the river, the valley is a mile or more in width, the river being bordered by broad, alluvial flats which at times of very high water may be completely flooded.

While the larger streams were able to deepen their valleys, even in the hardest rock, and continued to flow across the strike of the strata, the secondary streams were not strong enough to maintain their courses in opposition to the forces tending to divert them into conformity with the structure. As a result, these streams were gradually diverted to the areas of softer rock, and this adjustment was more readily brought about as the original direction of flow was more nearly parallel to the rock structure.

It was through this struggle between the eroding power of the streams and the slowly rising land surface that the existing surface configuration was developed.

At present the larger rivers of this area are, in some places, cutting their channels deeper, while at others, as evidenced by the large islands and wide areas of bottom lands, they have begun to deposit part of their burden. The valleys are slowly being widened, chiefly through the decomposition and disintegration of the rocks under atmospheric agencies.

The smaller streams have not yet cut down through the decomposed material to fresh rock, but the rate at which they are now cutting is probably in most cases greater than that of decomposition.

Evidence of the former position of the rivers is furnished by deposits of water-worn gravel, representing the remains of old river terraces, that are found at various places high above the present level of the river. One of these old river terraces, some 200 feet above the present river bed, is located near Stearnes on the north side of James River, where it can be traced up stream for a distance of about a mile.

A profile of James River shows a rather sharp change in the grade, where the river crosses from the sedimentary rocks to the granite, just

below Bremo Bluff.[a] From Lynchburg to this point, a distance of 80 miles, the river falls an average of 3.71 feet per mile, while flowing over the granite from this point to Lorraine, 12 miles above Richmond, which is a distance of 91 miles, the river falls only .606 feet per mile. In both cases the grade is fairly uniform. The change is too sharp to be accounted for by the natural increase in the grade of the stream with its distance from the mouth, and is probably due to the difference in the character of the formations. Another possible explanation is that the tilting of the peneplain has not been uniform, but this would hardly account for the localization of the change in grade at this particular point. There is no evidence of faulting, and the rock exposures along the bluffs are particularly good in this vicinity, so that it would probably show if present.

[a]See Plate VI, opposite p. 94, Hydrography of Virginia, Bull. No. III, Geol. Survey of Virginia, 1906.

CHAPTER IV.

STRUCTURE AND METAMORPHISM.

INTRODUCTION.

Previous descriptions have brought out the fact that the dominant rock formations occur in zones or belts extending in a northeast and southwest direction, and dipping at high angles, usually toward the east. Sedimentary rocks, from the manner of their formation, are necessarily laid down in nearly horizontal beds; but, in the region under consideration, the older rocks have been subjected to severe compressive stresses which have crumpled and squeezed the beds into close folds, mashing even the hardest rocks into schists and gneisses. The rocks have also been profoundly altered by the intrusion of large igneous masses. Subsequently erosion has gradually removed the overlying material, beveled off the edges of the upturned beds, and in places exposed the underlying igneous intrusives.

The lack of accurate knowledge concerning the structural relations of the rocks in the surrounding territory, and the scarcity of exposures, due to the great depth of residual rock decay, make it impossible to work out many of the details of structure in the limited area considered in this report, but some of the more important features will be discussed below.

STRUCTURAL FEATURES.

Folding.

There are three well-defined belts of pre-Cambrian metamorphic rocks of sedimentary origin, which consist essentially of knotted schists and interbedded quartzites. The most easterly of these belts extends southwest from Shannon Hill to Stage Junction; the middle belt is exposed in the river bluffs near New Canton and extends in a northeast and southwest direction approximately parallel to the first; the third belt is located along the northwestern margin of the map (Pl. I) between Palmyra and Strathmore. This areal distribution of the rocks is strongly suggestive of folding, and there are a number of facts which indicate that there is an anticlinal fold between the eastern and middle belts, and a synclinal fold between the middle and western belts.

In the eastern belt the rocks dip southeast at an average angle of 45°, in the central belt they stand nearly vertical, and in the western belt they

dip at an angle of 75° to 80° southeast. The central and western belts are separated by the long narrow area of Ordovician sediments, which were deposited unconformably upon the eroded surface of the older pre-Cambrian rocks; the eastern belt is almost entirely cut off from the other rocks by the large areas of intrusive granite (see p. 102).

The crustal movements continued with less intensity after the deposition of the Ordovician sediments, and these beds were compressed into the synclinal fold to which they owe their preservation. The Ordovician slates are extensively faulted and crumpled into innumerable minor folds, but the synclinal nature of the belt is shown by the presence of a basal conglomerate along the contact with the older rocks on both sides. The close folding and faulting shown in the section along the south side of James River (see Pl. VII) indicates that the beds were probably of no great thickness, and that they could not have been folded under conditions of very deep burial. The lack of a well-developed slaty cleavage in slate from the bottom of the synclinal trough has been commented on in a previous chapter (see pp. 45-46).

In the time that has elapsed since their deposition and subsequent folding, erosion has removed all of the Ordovician sediments except the long narrow belt of rocks, preserved in the bottom of the synclinal trough. Rivanna River has cut completely through this narrow remnant and exposed the underlying granite, thus proving the shallow character of the formation. In the railroad cut, half a mile south of Carysbrook, the Ordovician sediments are exposed resting on the eroded surface of granite (see Pl. VI, fig. 1), and as the river is approached the beds gradually thin out until they completely disappear. The slates are again exposed along the upper portion of Long Island Creek between Palmyra and Wilmington; and the creek, which in both its upper and lower portions is in direct alignment with the strike of the rocks in the two areas, probably owes its position to the slate belt, now partly removed by erosion.

The small detached slate area, paralleling the main belt a short distance north of Fork Union station, probably represents a minor fold which has been separated from the main belt by erosion; and minor folding offers the most plausible explanation for the widening of the slate belt in the section along the south side of James River.

It is not unlikely that there are numerous subordinate folds superimposed on the major folds of the pre-Cambrian rocks, but the nearly isoclinal dip, together with the lack of exposures, makes it impossible to work out minor details of this character. The presence of these minor folds is occasionally indicated by discordance between the bedding and schistosity —shown in Spec. 342 from the Buckingham mine.

Faulting.

Small faults, usually of the thrust type, are plentiful in the Ordovician slates and may be seen at many points in the bluffs along James River; they have also been detected in the pre-Cambrian rocks, and it is probable that many are concealed by the steep monoclinal dip of the bedding and schistosity. All the faults observed are approximately parallel to the strike of the rocks and it is unlikely that many of them cut across the structure. No large faults were definitely located along the boundaries between different formations although it is not improbable that such faults exist in a few places.

Some faulting has taken place in this region as recently as Triassic times, for a number of faults have been discovered in the Farmville area (see p. 47), as well as in the other Triassic areas of Virginia. The displacement along these recent faults, however, is comparatively small and they do not seem to have affected the structure of the country in any important way. The occurrence, during the past few years, of several feeble earthquake shocks in the vicinity of Arvonia is possibly due to adjustments that are taking place along some of these fractures.

The determination of faults in the granites and related igneous rocks is a more difficult problem, but the presence of cemented breccia on the Hughes farm, 2½ miles west of Tabscott, and on the Dickey farm, 2 miles southeast of Cremona, indicates that fracturing with more or less faulting has taken place at these points.

Jointing.

Joints are very plentiful in all portions of the area mapped, and, while they run in every conceivable direction, they show a decided preference for certain quarters of the compass. Joints having a general northeast-southwest strike, approximately parallel to the schistosity, are most common and those with a northwest-southeast trend are second in importance. North-south and east-west strikes are comparatively rare.

As a general rule joints are more closely spaced in the rocks of sedimentary origin than in the more nearly massive and compact rocks of igneous origin. For example, in the railroad cut half a mile south of Carysbrook, where Ordovician sedimentaries are exposed resting on the eroded surface of the older granite, the principal directions of jointing are N. 25° E., N. 60° W., and parallel to the contact which dips southeast at an angle of less than 30°. In the granite the joints are spaced 2 to 4 feet, while in the slate they are only 2 to 8 inches apart.

Schistosity.

Schistosity is that property of rocks which causes them to break most readily along certain parallel planes, and is due to mashing accompanied by more or less recrystallization of the mineral constituents. It is usually induced by the same compressive forces which result in folding and faulting, and is therefore parallel to the axes of the major folds.

With certain exceptions, noted later, the strike of schistosity throughout the region mapped, is northeast-southwest at slightly varying angles, and the dip is usually steeply inclined toward the southeast. In the pre-Cambrian rocks of sedimentary origin the schistosity is almost always parallel to the strike and dip of the bedding; and the few exceptions to this rule which were noted are probably due to the presence of subordinate folds superimposed on the major folds. There are greater variations in the relation of schistosity to bedding in the Ordovician slates than in the older rocks, for these have not been subjected to such severe compression and the dip of the bedding is therefore less uniform.

On the Stage Junction road, a mile north of Columbia, there are a number of rock exposures in the vicinity of the contact between the intrusive granite and the older pre-Cambrian schists and quartzites. In these exposures the strike of the schistosity is approximately parallel to the contact, varying from N. 15° to 24° W., and dipping southwest at an angle of about 45°. This exception to the general trend of the schistosity affects both the sedimentary and the igneous rocks and is probably due to the intrusion of the latter.

In most places the boundary of the granite area runs in a general northeast-southwest direction, approximately parallel to the strike of the bedding and schistosity of the neighboring sedimentary rocks; and in the few places where the contact cuts across the strike of the latter, the exposures are not sufficient to determine whether the anomaly described above holds true in other localities or not.

A peculiar form of schistosity was observed in slate from the bottom of a synclinal fold (see pp. 45-46). Instead of the usual slaty cleavage it has a prismatic cleavage, which causes the rock to break with equal readiness in all directions parallel to the axis of folding, while it breaks with much greater difficulty at right angles to this axis.

The schistose structure possessed by most of the granites and related igneous rocks of the district, was probably induced by pressure or mashing of the massive rock, but the gneissoid banding shown in certain localities (see Pl. VIII, fig. 1) is evidently a primary flow structure. In

the Elk Hill complex (see p. 57) granite occurs in the form of inumerable dikes, varying from a few inches to 50 feet or more in width, which have been intruded into the hornblende schist; and while for the most part the granite follows the planes of schistosity in the older rock it occasionally cuts directly across. Some of the granite dikes have a much contorted gneissic banding; and since the contortions are not shared by the older schist, they can not be explained by pressure, and must be due to movements in the partly solidified granite.

Structural Relations of the Granite.

Granite is a rock which forms only under conditions of deep burial, and therefore a large amount of overlying material must have been removed by erosion in order to expose the present surface. There is nothing to indicate that the material removed was essentially different from the formations that remain in contact with the granite, and that certainly in places overlie it. From this it should not be inferred that these same sedimentary formations necessarily extended for an indefinite distance toward the east; but it is believed that they formerly covered the granite in the immediate vicinity of the contacts, and that they once covered the large areas, such as the one lying between Stage Junction and Fork Union, which are still partly or wholly surrounded.

The areal distribution of the two formations indicates that the contact between the granite and the pre-Cambrian sedimentaries is not a uniform plane, but that the granite rises higher along certain lines that probably represent anticlinal folds. Such a line connects the granite embayment heading near Wilmington with the area lying between Kent's Store and Tabscott, and there is evidence that the intervening region is underlaid with granite at no great depth. The sedimentary rocks in the region between these two granite areas are intensely metamorphosed, hornblende schists are common, and there are numerous intrusive bodies of porphyry and pegmatite. The latter, which are probably differentiates from the underlying granite, are limited to this particular region and do not occur in the schists on either side. Some of the facts indicating the presence of an anticlinal fold in this vicinity were given in a previous paragraph, and it is interesting to note that the gold veins are located chiefly in the limbs of these folds not far from the granite contact.

In the southern portion of the area mapped the exposure of granite at the Greeley mine, a mile southwest of Gravel Hill, is in direct line of strike with the Rosney granite area; and the sedimentary rocks lying

between these two localities show evidence of contact metamorphism. Some of the rocks, as at Tower Hill, are largely altered to garnet and sillimanite, and tourmaline-bearing quartz veins are plentiful. It is believed that granite closely approaches the surface along this northeast-southwest line, and that the few exposures which occur are located where erosion has removed the overlying cover of sedimentary rocks. It is probable that much of the pre-Cambrian sedimentary area is underlaid with granite at greater depths.

Relations of the Hornblende Schists to the Granites.

Hornblende schists are plentiful in the Columbia granite area and in the Elk Hill complex, but are rarely found elsewhere in the area of granitic rocks; their distribution and occurrence have been described in detail in a previous chapter. There are two hypotheses that may be offered in explanation of the presence of these schists: (1) They are due to the partial solution and recrystallization of inclusions of the country rock, and (2) they represent segregations from the original granite magma. No chemical analyses are available, but all of the field and petrographic evidence is in favor of the latter hypothesis.

One of the chief objections to the first hypothesis is that, while the schists are more plentiful near the boundary of the granite area, there is no noticeable variation in their abundance or in their mineral composition consequent upon changes in the character of the sedimentary rocks along the contact. Moreover, they are abundant in the Elk Hill complex, which is situated far from the contact with sedimentary rocks. Another serious objection is the fact that the central portions of even the largest hornblende areas show no evidence of a sedimentary origin.

On the other hand, the areas of hornblende schists vary in abundance and size with the mineral composition of the granite; they are most plentiful in the southern portion of the Columbia area where ferromagnesian minerals, especially hornblende, are abundant in the granite, and they are absent in the embayment between Wilmington and Carysbrook, where the ferromagnesian minerals are at a minimum. The reasons for believing that the granite near Carysbrook solidified later than the rock in other portions of the area were given on pages 62-63, and the field evidence is conclusive in showing that the hornblende schists crystallized prior to the complete solidification of the associated granite.

The hornblende schists are remarkably uniform in mineral composition, and the variations from the normal are all intermediate between the

granite and the typical schist. Occurrences showing a gradation of granite into hornblende schist were described in detail in a previous chapter (see pp. 66-68). On approaching a large area of hornblende schist the potash feldspars and muscovite disappear from the granite and finally hornblende gradually takes the place of biotite.

It seems probable that the hornblende schist and granite of the Elk Hill complex belong to the same period of intrusion as the rocks of the Columbia area, for they are similar in appearance and mineral composition. Another fact, which lends support to this supposition, is the absence of hornblende schists along the contact between the Columbia area and the pegmatite belt, although the schists commonly constitute a border facies of the granite. This suggests that the Elk Hill complex may represent the real eastern border of the Columbia granite and that the intervening pegmatites may be residual differentiates from a common magma.

As yet little is known of the processes by which rock magmas are differentiated into rocks differing widely in mineral and chemical composition. In the absence of numerous chemical analyses of the rocks it is impossible to discuss the various theories of rock differentiation and their application to the present problem; but some of the more important facts concerning the differentiation of the hornblende schists will be summarized, and the probable processes will be briefly outlined.

The hornblende schists crystallized prior to the granites with which they are associated, and they are more plentiful where the granite is hornblende-bearing. In the Columbia area the hornblendic granites probably solidified prior to the granites containing little or no hornblende. Where hornblende occurs in the granites it is one of the minerals of early crystallization. The bodies of schist vary in size from small schlieren up to areas that are over a square mile in extent, and they are most abundant in the marginal portions of the granite area.

The hypothesis outlined below, while only tentative in its nature, is based on the facts given in the previous descriptions, and serves to explain the observed relations between the hornblende schists and the associated granite. As the original magma gradually cooled, crystallization began in the border portions where the temperature was lowest, the more basic minerals separated out first; and in this way the marginal areas of hornblende rock were formed. Differential movements, occurring after the basic border facies of the magma had partly or wholly crystallized, resulted locally in the intrusion of the still-fluid portions of the magma into the

solidified rock, and caused the interleaving of the two rock types that is such a prominent feature of the Elk Hill complex. The detached areas of hornblende schist found within the central portion of the granite may represent material derived from the border portions, or possibly they are due to segregations *in situ*.

The differential movements mentioned above may have brought portions of the solidified rock into contact with magma having a higher temperature and resulted in some resolution. This possibly explains the occurrence of intermediate rock types with unusual coarse textures, for when recrystallization followed upon partial solution any undissolved crystals would prevent supersaturation, which is commonly the cause of rapid crystallization and fine texture.

It is believed that the granite near Carysbrook, which is low in ferromagnesian minerals and contains no marginal areas of hornblende schist, was intruded in a partly crystallized condition (see pp. 62-63), and was the final portion of the magma to solidify.

METAMORPHIC FEATURES.

Regional Metamorphism.

All the older rocks in the area studied, both those that are sedimentary and those that are igneous in origin, have been deeply buried in the anamorphic zone, and most of them show pronounced effects of dynamic metamorphism. Megascopically these effects are manifested chiefly by the development of a schistose structure, which in some instances is accompanied by gneissoid banding. In a rough way the degree of alteration is proportional to the age of the rocks; the pre-Cambrian sediments are the most schistose, the Ordovician rocks show less effects, and the Triassic rocks are practically unaltered. The degree of schistosity is also dependent on the composition and original texture of the rock. The pre-Cambrian quartzites, for example, are almost massive, while the fine-grained schists with which they are interbedded have a highly developed cleavage and almost perfect parallel orientation of the mineral constituents.

Microscopically, the chief evidence of dynamic metamorphism is furnished by the fracturing, granulation, and optical distortion of certain minerals, by recrystallization, and by the complete or partial alteration of primary to secondary minerals, such as sericite and chlorite.

The development of the pseudophenocrysts that occur in the knotted schists took place under mass-static conditions, for these minerals are of later formation and show no regular orientation relative to the schistosity of the rock.

Since the metamorphism of the different rock types has already been considered in the chapter on descriptive geology and petrography, a detailed discussion will not be given here. While the alterations outlined above have been attributed chiefly to mass-mechanical action under conditions of deep burial, it is probable that the changes have been greatly aided by the intrusion of the vast masses of igneous rock, only part of which have been exposed by erosion.

Contact Metamorphism.

INTRODUCTION.

Under contact metamorphism, those changes will be discussed which are set in action by intrusive masses of molten rock. The metamorphism of the wall rock is manifested by recrystallization, usually with the production of new and characteristic minerals, and by changes in texture; the effects are at a maximum near the intrusive and decrease in intensity with the distance from the contact. The intrusive likewise shows more or less variation in texture and mineral composition as the contact is approached.

It is now generally believed that the changes which take place in the vicinity of igneous intrusives are due chiefly to the action of highly heated water and other mineralizers set free by the solidifying magma. These highly heated vapors or gases, probably carrying a certain amount of silicates and other substances in solution, penetrate the surrounding rock through minute fractures and pores, bring about the formation of new minerals, and deposit their dissolved material. Acid magmas, such as those from which granites crystallize, are supposed to be richly provided with these mineralizers, and therefore commonly produce greater effects than more basic magmas.

All the older rocks in the James River basin have been subjected to intense dynamic metamorphism and it is often difficult to distinguish between alterations due to this cause and those due solely to igneous intrusives. The diabase dikes, and other small masses of intrusive igneous rock, have produced practically no effect on the sedimentary rocks along their contacts, but in the vicinity of the granite area the older rocks have been intensely altered by contact action. Because of the lack of good exposures, there are only a few places where the contact between the granite and the sedimentary rocks can be observed and studied; the best of these is furnished by the bluffs along James River and Phelps Creek in the vicinity of New Canton. The rocks in this locality will now be described in detail.

DETAILED DESCRIPTIONS OF CONTACT PHENOMENA.

JAMES RIVER SECTION ACROSS GRANITE CONTACT.

On the south side of James River near New Canton, the contact between the granite and the pre-Cambrian sediments is marked by a belt of hornblende schists, 700 to 900 yards wide, part of which are sedimentary in origin, while part represent a basic border facies of the granite. In the absence of chemical analyses it is impossible in many cases to distinguish between the rocks that are igneous and those that are sedimentary in origin, and indeed they are to a certain extent interleaved with one another; therefore the line drawn on the map (Fig. 2) to show the contact between the two formations is only approximate. On the east side, the hornblende schists pass into granite, while on the west they grade into the knotted schists which are interbedded with quartzites.

The quartzites are described in detail on pages 16-18, and the knotted schists on pages 30-34. At a distance from the contact the knots or eyes present in the schist consist of impure siderite; about 900 yards east of the hornblende schists, biotite begins to take the place of siderite in the eyes, and within 600 yards of the hornblende schists garnets appear. The change is one of gradual increasing intensity of metamorphism as the contact is approached; but there is one exception to this rule—the knotted schists occurring along the east side of the quartzite, about 700 yards from the hornblende schists, are intensely altered in the immediate vicinity of their contact with the quartzite, probably because the latter rock, being more porous, has furnished a channel for the circulation of the heated solutions expelled from the cooling granite.

About 300 yards southeast of Bremo bridge, an old tunnel, said to have been opened in prospecting for iron, exposes the rock along the east side of the quartzite. Near the schist the quartzite contains numerous garnets, and the quartz appears to be completely recrystallized. Adjoining the quartzite there is a bed of highly garnetiferous rock, 4 to 12 feet wide, which grades into the typical knotted schists. The strike of the schists is N. 23° E. and the dip practically vertical.

The altered rock (Spec. 456) near the quartzite is dark gray to brown in color, and consists of numerous red garnets, ranging up to 4 mm. in diameter, fine-grained quartz, radiating crystals of dark gray sillimanite, and a little dark green chlorite. Examined in thin sections under the microscope the garnets are light pink to nearly colorless, contain numerous inclusions, are irregular in outline, and show partial alteration to chlorite

in their border portions and along fractures. Some are quite clear while others are rendered almost opaque by clouds of dust-like inclusions (magnetite or hematite), which are frequently confined to the central portions leaving the borders clear. Some of the garnets also contain numerous included quartz grains. Quartz, which is the second mineral in relative abundance, has been completely recrystallized and occurs in irregular grains showing strain shadows. The sillimanite is mostly arranged in radiating clusters of prismatic crystals. Magnetite, hematite, and a little pyrite are present as minor accessories.

Other exposures are furnished by several surface pits located along the same line of strike, a mile southwest of New Canton; and here the garnet rock may be seen grading on the east into the knotted schists containing scattered eyes of garnet. The rock (Specs. 465 and 466) from these openings is dark reddish-brown in color and consists chiefly of garnets with less quartz, sillimanite, cyanite, chlorite, magnetite, hematite, and pyrite present in the order named. The garnets (almandite) are large, imperfectly formed, and contain numerous inclusions of quartz and iron oxide. Under the microscope they frequently show irregular branching radii of clear mineral which spread out from the center and separate areas that are full of inclusions. As these radii recede from the center they branch into a vein-like network, which grades without definite boundaries into the surrounding ground-mass, consisting of quartz, garnet, and magnetite. Another form of garnet (possibly spessartite) is so full of dust-like inclusions of magnetite with a little quartz, that they are rendered almost opaque. These inclusions show a zonal arrangement, and in some of the garnets the zonal bands are broken and contorted as though by crushing. Sillimanite is present in radiating groups of fine-bladed crystals, and cyanite occurs in large-bladed prisms, which frequently show multiple twinning and contain dust-like inclusions of iron oxide.

A garnet-sillimanite rock, similar to that just described, outcrops along the road near Hatcher Creek, a mile south of Gravel Hill postoffice, and also near the summit of Tower Hill, 2½ miles southwest of Gravel Hill.

Passing eastward from the quartzite, knotted schists are exposed in the river bluffs for several hundred yards. Specimen 307, taken from an outcrop 200 yards east of the quartzite and 800 yards from the contact, contains numerous eyes of biotite and only occasionally a small garnet. A detailed petrographic description of the rock is given on pages 32-33. About 300 yards farther east the schist (Spec. 306) is light bluish-gray in color, slightly coarser grained, and contains scattered eyes of garnet 1 to 2 mm.

in diameter. Specimen 305, taken about 400 yards from the contact, is of light gray sericitic schist containing garnets 2 to 4 mm. in diameter, and occasional flakes of biotite about 1 mm. in diameter.

Near Phelps Creek and about 300 yards from the contact hornblende begins to be plentiful in the schist, occurring in dark green crystals that range from small grains up to prisms 3 or 4 mm. in length. The rock (Specs. 303 and 304) is mostly fine-grained and compact, breaking readily along closely spaced joints. The minerals distinguishable megascopically are quartz, hornblende, chlorite, sericite, much pyrite, and a little magnetite. The New Canton copper mines are located directly in line of strike with these rocks and therefore the large amount of pyrite present is significant. Petrographic descriptions of rocks from the different copper mines are given on pages 250-256.

Near the second railroad bridge over Phelps Creek and about 250 yards from the contact the schist (Spec. 301) is a fine-grained, dark greenish-gray rock, speckled with numerous, well-formed, red garnets 0.5 mm. in diameter, and containing occasional lenses of pyrite 2 or 3 cm. in length. With the aid of a pocket lens small needles of hornblende, oriented parallel to the schistosity, and fine-grained quartz are seen to make up the greater part of the rock-mass. At the Margaret mine and about the same distance from the contact a quartzitic rock was found which contains irregular crystals of dark green hornblende and light greenish-brown needles of sillimanite.

In the bluff on the east side of Phelps Creek, and about 150 yards from the contact line shown on the map (Fig. 2), an apophysis or dike from the granite is exposed. It is perhaps 20 feet in width and parallels the inclosing schists in strike and dip. The rock (Spec. 426) is light gray in color, fine-grained, and highly schistose; it is composed essentially of white feldspar, quartz, and flakes of black biotite, which are oriented parallel to the schistosity and are much more plentiful in some portions of the rock than in others. A little garnet and magnetite may also be distinguished megascopically. Examined microscopically the rock is seen to be slightly porphyritic in texture, containing feldspars that range up to 2 mm. in length. The feldspars are all plagioclase (albite-oligoclase or oligoclase) and are for the most part unstriated, but occasionally both Carlsbad and albite twinning can be distinguished. The biotite is light greenish-brown in color, strongly pleochroic, and some of the flakes are nearly as large as the feldspars. The ground-mass is composed of feldspar, quartz, biotite, a little chlorite, small pink garnets, and a few grains of magnetite and irregular zircons.

Along the contact between the granite dike and the hornblende schists there is a layer of rock (Spec. 427), only a few inches thick, composed largely of bright green chlorite and well-formed garnets ranging up to 0.75 cm. in diameter. Under the microscope the garnets are seen to contain numerous inclusions of quartz and magnetite. None of the chlorite is derived from the garnets, for the latter are all fresh and unaltered. Quartz occurs in lenticular eyes and as small veinlets between the cleavage planes of the chlorite. Fluid inclusions, usually with bubbles, are plentiful and some are comparatively large. Scattered grains of magnetite and a little sericite make up the accessories.

About 50 yards southeast of the granite dike and within 100 yards of contact line shown on the map, the rock (Spec. 428) is light gray, fine-grained, close-textured, and distinctly schistose. It contains well-formed pink garnets ranging up to 2 mm. in diameter, and with the aid of a pocket lens small needles of green hornblende, quartz, and much fine-grained magnetite may be distinguished.

Under the microscope the magnetite is seen to occur in idiomorphic grains which are scattered through the rock without reference to the other minerals; the hornblende occurs in slender needle-like prisms, occasionally showing sections with crystal outline; and the quartz is present in irregular grains filling the interstices between the other minerals. Scattered through this ground-mass there are a few comparatively large irregular crystals of acid plagioclase feldspar, ranging up to 2 mm. in diameter. They are very ragged in outline and poikilitic in texture containing numerous small inclusions of quartz and to a lesser extent of the other minerals. The hornblende needles occasionally project into the feldspars, but are usually pushed aside by them. The feldspars are partly oriented with their greater elongations parallel to the schistosity, they rarely show fine albite twinning, and are usually unstriated. A little chlorite is present as an alteration product of hornblende.

The rock (Spec. 429) 30 yards south of that last described is dark green, even-granular, and more nearly massive in texture. Under the microscope it is seen to consist of hornblende, feldspar, quartz, and a little magnetite and pyrite, in the order named. Hornblende, which is dominant, occurs in irregular, elongated prisms only partly oriented parallel to the schistosity. The feldspar is all acid plagioclase with an index of refraction approximately the same as quartz, and is partly unstriated and partly twinned after the albite law. A small amount of chlorite is present as a secondary mineral. In the absence of chemical analyses it is impossible to say whether the rock is sedimentary or igneous in origin.

The rocks exposed in the bluffs along the east side of Phelps Creek as far south as the county road are all hornblende schists varying slightly in coarseness of texture. In places narrow dikes of quartz porphyry containing much biotite are interleaved with the hornblende schists.

About 60 yards northeast of the road bridge, and within 50 yards of the contact as shown on the map, the rock (Spec. 433) is dark green, fine-grained, close-textured, and contains much pyrite in scattered cubes, ranging up to 3 mm. in diameter. Examined microscopically the rock is seen to consist of quartz, hornblende, magnetite, a little plagioclase feldspar, and some secondary chlorite. The magnetite is present in idiomorphic grains evenly distributed through the rock; the hornblende is almost as plentiful as the quartz, occurring in needle-like prisms that are imperfectly oriented parallel to the schistosity; and the quartz fills the interstices between the other minerals and occasionally forms lenticular eyes, 1 mm. in diameter. Both hornblende and magnetite are present as inclusions in the quartz. A little acid plagioclase showing albite twinning may be identified in places but is not plentiful.

Specimen 434 was obtained from the bluffs facing the low ground on the south side of James River and about 75 yards east of the line of contact as shown on the map (Fig. 2). The rock is a dark gray, fine-grained hornblende schist containing streaks due to elongated segregations of the light-colored minerals. It is cut by closely spaced joints, which cause the rock to break into small rhombic shapes. Examined under the microscope, hornblende is seen to be dominant, occurring in slender prisms which occasionally show idiomorphic cross sections and are usually oriented parallel to the schistosity. They show good cleavage and are practically free from inclusions. The interstitial spaces are filled with acid plagioclase, quartz, and magnetite. The feldspars are clear, seldom show cleavage or twinning, and have an index of refraction slightly less than balsam, corresponding to albite or albite-oligoclase. Quartz is present as a minor constituent, magnetite occurs in small scattered grains, and there is a little chlorite present as an alteration product of hornblende.

A hundred yards farther east the hornblende schist (Spec. 435) is much coarser in texture. It is a heavy rock, dark green to black in color, and contains hornblendes ranging up to 6 mm. in diameter, numerous grains of magnetite, and occasional light-colored spots, consisting of fine-grained, light green epidote. Under the microscope the hornblende, which makes up the greater portion of the rock, is strongly pleochroic in shades of dark green, blue, and greenish-brown; it has good cleavage but poor

crystal form, and frequently contains numerous inclusions of quartz and magnetite. Magnetite is the second mineral in relative abundance, occurring in small angular grains and in larger masses which occasionally contain inclusions of hornblende. Epidote is present in small grains and granular aggregates, almost colorless and only slightly pleochroic. Quartz is sparingly present in small grains and chlorite occurs as an alteration product of hornblende.

Fine-grained hornblende schist, over 100 yards in width, intervenes between the coarse-grained schist and the granite, which first appears about 400 yards east of the line showing the approximate contact between the sedimentary and igneous rocks. In the road half a mile south of New Canton a coarse-grained hornblende schist, containing a much larger percentage of feldspar than the rock described above, is exposed close to the granite.

The granite (Spec. 438), exposed in the river bluffs near the hornblende schists, is dark gray, fine-grained, and very gneissic in structure. The minerals recognizable megascopically are feldspar, quartz, biotite, many small pink garnets, and a few scattered grains of hornblende and magnetite. A specimen (439) obtained about 200 yards farther east is much lighter in color. It has well-developed gneissic banding, and sericite is very prominent, while biotite is relatively scarce. Examined microscopically it is seen to consist of acid plagioclase, quartz, sericite, biotite, garnet, a very little hornblende, and the secondary minerals epidote and chlorite. There seems to be no potash feldspar present. Other specimens of the granite from this vicinity are described on pages 71-72.

On the opposite side of James River the marginal belt of hornblende schist is narrower, but there are several small elongated areas of hornblende schist included within the granite. Continuing northeast along the contact the belt of hornblende schists gradually becomes narrower and a short distance south of Fork Union entirely disappears.

Rivanna River Section Across Granite Contact.

The contact between the granite and the sedimentary rocks is fairly well exposed in the bluffs on the south side of Rivanna River, a mile northwest of Carysbrook. A quarry has been opened in the granite within less than 100 yards of the contact, and the rock exposed in the opening is described in detail on pages 75-77. The contact can be located with an error of less than 20 feet, but there is little if any evidence of contact metamorphism. The granite is probably a little finer grained than that

exposed in the quarry, and contains more pyrite. The sedimentary rock is a chloritic slate which near the contact is slightly coarser grained, more siliceous, and less regular in its cleavage, but all of these differences may be due to other causes than contact metamorphism.

No evidence of faulting is visible, and the textural and structural relations of the slate indicate that it is older than the granite. The lack of pronounced evidence of contact action is probably due to the fact that the sedimentary rocks were intensely altered by dynamic metamorphism, prior to the intrusion of the granite, which must have been much cooler than the granite near New Canton. On pages 62-63 evidence was presented to show that the granite near Carysbrook was intruded and solidified at a later date than the granite farther south; and both the megascopic and microscopic evidence (see pp. 75-76) indicates that this granite was intruded in a partly solidified condition.

Veins.

Quartz veins are of frequent occurrence in the sedimentary rocks near their contacts with the granite, and, where not exposed, their presence is commonly indicated by an abundance of quartz float on the surface. North of James River these veins contain soda-lime feldspars, muscovite, a little tourmaline and other minerals indicative of a magmatic origin, and they usually carry small quantities of gold; south of the river tourmaline is very abundant in many of the quartz veins. Some of the veins are accompanied by more or less metasomatic replacement of the wall rock, and an extreme example of this replacement is furnished by the sulphide bodies near New Canton. The walls of some of the veins show evidence of metamorphic action similar to that found near the granite contacts, but on a smaller scale. The gold-bearing veins are described in detail in chapter V.

Willis Mountain.

On the southwest slope of Round Mountain (the southern knob of Willis Mountain) the schists in the vicinity of an intrusive diorite show pronounced effects of contact action. The exposures are limited to two shafts 40 to 50 feet deep, located about 100 yards apart in an east and west direction, which were sunk in prospecting for copper. The size of the diorite body could not be ascertained because of the insufficiency of exposures, but the coarseness of texture indicates that it is probably large.

Megascopically the diorite (Spec. 390) is a massive dark gray rock composed essentially of dark green hornblende in irregular prismatic

crystals ranging up to 1.5 cm. in length, white feldspars, which frequently show multiple twinning, numerous red garnets about 1 mm. in diameter, with more or less pyrite and pyrrhotite. In places the rock is cut by narrow intersecting veinlets, some of which are composed of white feldspars, 2 to 3 cm. in diameter, with more or less pyrite and pyrrhotite, while others consist chiefly of white, even-granular calcite. The latter range up to 6 or 7 inches in thickness. There are also occasional streaks or bands due to the presence of unusual amounts of garnet, or, more rarely, epidote.

Examined microscopically the hornblendes are light green in color and contain numerous inclusions, principally feldspar and quartz. The feldspars show beautiful twinning after the albite and pericline laws, and in composition are probably intermediate between andesine and labradorite. Most of the garnets show good crystal form; they are slightly altered along fractures with the production of chlorite and calcite. A little light brown biotite, elongated grains of rutile, ilmenite partly altered to leucoxene, and occasional zircons make up the minor accessories.

The typical cyanite and quartz-sericite schists constituting Willis Mountain have been described in a previous chapter (see pages 25 and 27-28). The schist (Spec. 389) near the diorite is a light brown, fine-grained rock, heavily impregnated with pyrite in cubical crystals ranging up to 2 or 3 mm. in diameter. The other minerals recognizable megascopically are light brown biotite, a scaly micaceous mineral, colorless to light gray or green (probably chlorite), a few prismatic grains of rutile, and a little nearly colorless cyanite.

Under the microscope the light-colored mineral (chlorite), which is probably dominant, has very low interference colors and frequently occurs in radiating scales. The biotite is very light brown in color and rather weakly pleochroic; in places it contains needle-like prisms of rutile. Soda-lime feldspar, intermediate between andesine and labradorite, is the third mineral in relative abundance and frequently shows twinning after both the albite and pericline laws. Cyanite is quite plentiful, rutile is abundant in prismatic crystals and irregular grains, and there is also much calcite present. The crystals of pyrite contain occasional inclusions of rutile but no other minerals. Zircons are present as unimportant minor constituents.

OUTLINE OF GEOLOGICAL HISTORY.

The complete geological history of this region can not be written until the rocks of the Piedmont province have been studied and mapped in greater detail; the record is fragmentary and complex, and much of it

may never be deciphered. In the older rocks of the area, which have been classified as pre-Cambrian, no fossils have been found, and if they were ever present, they have probably been destroyed by the extensive metamorphism that has affected the entire region.

Pre-Cambrian.

The history of the James River basin in pre-Cambrian times is shrouded in much doubt. It is not known whether the period of igneous activity, resulting in the formation of the basic rocks of the greenstone area, preceded or followed the deposition of the pre-Cambrian sediments. These sediments were laid down as sand and mud in shallow waters not far from the shore, as is indicated by the lenticular shape and sudden pinching of many of the quartzite beds, as well as their frequent repetition. The formation of pure quartz sands involves the complete decomposition of quartz-bearing rocks in order that the quartz grains may be separated from the other constituents, the latter going to form the fine clayey beds. Therefore most of the sediments were probably derived from a low-lying land area mantled with residual decay. These conditions, however, did not continue uniformly throughout the entire period of sedimentation, for the arkosic beds lying between Lantana and Pryors Crossroads were laid down under conditions that did not permit mature weathering.

After their deposition the sedimentary beds were compressed by powerful forces acting in a northwest-southeast direction; the effects of which were close folding, faulting, mashing, and recrystallization. These great crustal movements, which brought the pre-Cambrian period to a close, converted a large area within the limits of the North American continent into land. While the crustal movements were still in progress, and probably as another manifestation of the same orogenic forces, large masses of molten rock were intruded into the sedimentary formations.

Cambrian.

The period of igneous activity, which resulted in the intrusion and differentiation of the granites and their related rocks, continued until after the great crustal movements had ceased. The formation of the gold veins is believed to represent the final stage in the differentiation and crystallization of the granite magma.

The massive diorite dikes, which occur at several places in the area, were probably intruded during Cambrian times, but after this there ensued a long period of freedom from igneous activity.

During Cambrian and early Ordovician time the area was subjected to extensive denudation, the products of erosion probably going to build up the Cambrian formations to the west. This period of denudation resulted in the removal of thousands of feet of overlying material and the exposure of the deep-seated granite.

Ordovician.

In late Ordovician time portions of the Piedmont region were again depressed below sea level to receive the sediments of that period, but it is improbable that all of the area has been under water since its elevation at the close of the pre-Cambrian. The Ordovician sediments were laid down on the eroded surface of the older formations, the material being derived from the neighboring land areas of pre-Cambrian rocks. The limited thickness of the coarser sediments at the base of the series, in comparison with the overlying beds of slate, indicates that subsidence was rather rapid; and the presence of tuffaceous beds shows that the movement was accompanied by more or less volcanic activity, although there are probably no igneous rocks of this age present in the district.

The Ordovician period was closed by marked geographical changes which enlarged the land areas and raised the recently formed sedimentary beds above water. After the close of the crustal movements resulting in the folding and faulting of the Arvonia slate belt, the region seems to have entered upon a period of quiescence. While oscillations occurred in other parts of the country, the Piedmont portion of Virginia seems to have remained above water and to have suffered little if any deformation until after the close of the Carboniferous; and during this entire period peneplaination continued uninterrupted.

Triassic.

It seems probable that the Piedmont peneplain was but slightly affected by the Appalachian revolution. The surface was warped or faulted sufficiently to form the elongated trough-like depressions, roughly parallel to the coast, in which the sedimentary beds of the Triassic (Newark formation) were laid down. It is not believed that these deposits ever covered a large area, though it is possible and perhaps probable that the detached areas found in Piedmont Virginia were once connected with one another. The prevailing red color of the formations, the presence of coal beds, and the character of the fossils indicate that the sediments were deposited in fresh or brackish water and that they are not of marine origin. The

material composing these strata was derived principally from the residual decay of the neighboring crystalline rocks, which must have undergone extensive chemical decomposition after they had been reduced by erosion to a nearly level plain.

The deposition of the Triassic sediments was accompanied or immediately followed by the intrusion of the diabase dikes, which are of frequent occurrence throughout the Piedmont area.

Since Triassic time the surface has been slightly elevated, and there has been a little faulting, but no important crustal movements have occurred; degradation has continued without interruption down to the present day. The detailed history of the development of the existing surface features is given in the chapter on physiography.

CHAPTER V.

THE GOLD MINES OF THE DISTRICT.

INTRODUCTION.

Detailed descriptions of all gold mines in the district are given below, but because of lack of information some of the descriptions are not nearly so complete as others. When the region was studied by the writer most of the mines had long been abandoned and consequently few openings were accessible; development work was in progress at the Scotia, Tellurium, Waller, and Young American mines; an old shaft was being reopened on the Payne property; and a little ore had recently been mined from superficial workings on the Bowles tract. Some of the older mines have been described from time to time by geologists and mining engineers, and wherever information could be obtained from such sources it has been freely used. The mines on the north side of James River, in Goochland and Fluvanna counties, will be considered first, and then those located on the south side of the river in Buckingham County.

MINES IN GOOCHLAND AND FLUVANNA COUNTIES.

The Young American Mine.

Location.—The Young American gold mine is situated in Goochland County about 1½ miles north of Lantana and 6½ miles northeast of Columbia.

History.—The Young American, formerly known as the Gilmer mine, is said to have been discovered about 1869 by a Mr. Aldrich, who at that time was operating a saw mill on the property. After a little prospecting he sank a shallow shaft on a vein, now known as the "House" vein, and then built a small stamp mill to crush the ore. The mill had wooden stamp-stems with iron shoes, and was operated by the same engine that furnished power for the saw mill. Mr. Aldrich is reported to have made some money from the mine, but only worked it for a short time. Later gold was discovered in the branch that runs through the property and sluice and rocker washing was carried on during the period between 1871 and 1874.

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In 1880, the Tagus Gold Mining Company began development work and continued operations for three years. About 100 tons of ore found on the surface were hauled to the Belzoro mill and stamped, yielding a return of $5.00 per ton. The "House" vein was developed and stoped down to water level for a distance of approximately 600 feet along the strike, and some small lenses of quartz, paralleling the "House" vein about 100 feet to the west, were exposed by an adit and mined. The "Sulphur" vein, about 300 yards west of the "House" vein, was explored, several small shafts sunk, and much of the vein above water level stoped out. A 4-foot Bryan mill was installed to pulverize the ore. As no records are now available it is impossible to give authentic information in regard to the production and average value of the ore mined. According to one report the average value of the ore obtained from the "House" vein was $5.27 per ton, but another states that it averaged $10.00 per ton. They all agree that the ore from the "Sulphur" vein was lower in value.

From 1885 to 1909, when the present company bought the property, the mine passed through several hands, and while occasional attempts at development were made, very little ore was milled. It is reported that a cyanide plant was in operation in 1893, but with what success is not known.[a] The present company has reopened several of the old shafts and drives, sunk 2 shafts on the "Sulphur" vein to a depth of 84 and 100 feet, respectively, and done considerable development work, chiefly on the "Sulphur" vein. After making trial runs with the old Bryan mill, a new building was erected in 1910 and a Lane mill installed, but only about 1,500 tons of ore have as yet been milled.

Present equipment.—The mine is equipped with 2 shaft houses, a mill, and several other buildings. A steam hoist is located at each of the shaft houses, and there is an air compressor to furnish compressed air for the drills. The mill contains a Blake crusher, feeder, slow-speed Lane mill, and 2 Traylor concentrating tables.

Underground development.—The "Sulphur" vein, having a strike of N. 30° E., and an average dip of about 40° toward the southeast, is developed by 2 hoisting shafts and several air shafts, with underground drives that connect them and extend for a distance of 500 feet or more along the vein. The "Sulphur" shaft, sunk on top of the hill, in the hanging wall at a distance of 60 feet from the outcrop, is vertical to a depth of 80 feet where it intersects the vein, and then follows the vein on

[a]Nitze, H. B. C., and Wilkins, H. A. J., Gold Mining in North Carolina and Adjacent South Appalachian Regions, Bull. 10, N. C. Geol. Survey, 1897, p. 38.

an incline for about 42 feet, making the total depth below the surface 100 feet. About 75 feet from the surface, drives extend in either direction along the vein, connecting with the other shafts, and near the bottom of the incline 2 short drives run northeast and southwest. The "H. V." shaft, near the branch, 340 feet northeast of the "Sulphur" shaft, is vertical and 83 feet deep, the first 30 feet being on the vein, which here is nearly vertical for that distance. At a depth of 30 feet from the surface a drive along the vein connects with the "Sulphur" shaft, and 54 feet from the surface an 18-foot cross-cut running southeast intersects the vein, which at this point is further exposed by 2 short drives in either direction.

Practically all the stoping has been confined to the upper portion of the vein above the drive connecting the two hoisting shafts, and very little ore that would pay the cost of mining and milling remains in that part of the mine.

The "House" vein, outcropping about 250 yards east of the "Sulphur" shaft, is not at present accessible, but the old stopes and surface cuts have a strike of N. 22° E. A shaft, sunk about 350 yards southeast of the "Sulphur" shaft, did not strike the vein. Several adits have been driven under the hill near the north end of the old workings, and though they were not carried far enough to intersect the "House" vein, they expose a number of large lenses and stringers which approximately parallel that vein. The larger lenses encountered have been mined out above the water level.

General description of the geology.—There are almost no surface outcrops in the vicinity of the Young American mine, but there are many exposures along Big Byrd Creek, which cuts directly across the strike of the rocks, 3 miles southwest of the property. On the east side of the creek, about half a mile south of Bowles' bridge, rocks outcrop which are apparently identical with the country rock exposed in the underground workings of the mine, and they are in the same line of strike. These rocks are intensely metamorphosed schists and gneisses, derived from bedded sedimentaries, which were probably arkosic sandstones and grits. About three-quarters of a mile southeast of the mine this series of altered sedimentary rocks passes into and is interbedded with quartzites, which are in places highly ferruginous, containing both specular hematite and magnetite. Crystals of magnetite, consisting of octahedrons 1 cm. and less in diameter, which have weathered from the underlying rock, are found on the surface 300 yards northeast of the veins, and at several other localities on the property and in its immediate vicinity. The wall rock exposed in the mine usually contains much fine-grained magnetite.

The hornblendic border facies of the main granite batholith is exposed about a mile southeast of the mine, and what is probably a tongue from the latter comes within three-quarters of a mile or less, outcrops of granite occurring along the branch that runs about that distance northeast of the mine.

Two varieties of gneiss are exposed in the underground workings: The dominant type is a dark greenish-gray, fine-grained rock, usually banded, and composed essentially of quartz, feldspar, hornblende, biotite, and chlorite, with smaller amounts of magnetite, calcite, and sericite; the other, which is similar except for the absence of most of the iron-bearing silicates, is a fine-grained, light gray rock, composed essentially of quartz, feldspar, sericite, and smaller amounts of chlorite and calcite. The chief mineral constituents in these rocks, while varying somewhat in their relative proportions, are always the same.

In the openings on the "Sulphur" vein, the light-colored gneiss occurs as a bed, varying from 1½ to 8 feet in thickness and lying between strata of the darker gneiss. It was also found on the dumps of some small pits and shafts near the line of strike of the "House" vein, about 200 yards south of the Dietz shaft, but in most openings on the property that are now accessible the dark hornblendic rock is the variety exposed.

There are two principal veins on the property that have been worked for gold, the "Sulphur" and the "House" veins. In the vicinity of the "House" vein there is a large number of small stringers and lenses which have been mined to a limited extent.

The "Sulphur" vein at the surface has an average strike of about N. 40° E:, which is approximately the same as that of the country rock, but locally there is considerable variation, and in the underground workings near the Chittenden air shaft there is a sharp change in strike from N. 21° to 53° E. The dip is toward the southeast, changing from almost vertical in places near the surface to an angle of 30° in some of the lower workings, the average for the first 150 feet from the outcrop being about 50°. The width varies from 6 feet down to a few inches, and the average is probably between 2 and 3 feet. Where the vein is several feet wide it consists of a single mass of quartz, but elsewhere it frequently breaks up into a number of approximately parallel stringers and lenses, forming a belt 6 or 7 feet wide in which the country rock between the veinlets may be more or less mineralized. (See figs. 6 and 7.) In one instance noted, the veinlets instead of being parallel to the general inclination of the vein cut across it in such way as to suggest their formation in

a zone of shear faulting (see fig. 9, p. 130). Where exposed in the underground workings, the "Sulphur" vein occurs in the light-colored gneiss and also in both the overlying and underlying, dark, hornblendic gneiss.

The "House" vein, 200 to 300 yards east of the "Sulphur" vein, has a strike of about N. 22° E., which would cause the two veins to intersect if they both maintain their courses toward the northeast. The "House" vein is said to have an average width of 5 or 6 feet, but as the old workings have caved and are not now accessible this statement could not be verified. The strike was determined by means of the old surface cuts and caved stopes along the outcrop. Near the southwestern end of the old workings the country rock seems to be chiefly the light-colored gneiss or schist, but where the adits have been driven under the hill near the northeastern extension of the vein, the country rock, wherever exposed, is a dark green hornblendic gneiss, similar to that found in the openings on the "Sulphur" vein.

The adits, above mentioned, were not carried far enough to strike the "House" vein, but they cut through a large number of lenticular veinlets that apparently parallel the main vein. These veinlets range from stringers a fraction of an inch in width up to lenses 2 feet thick and 25 feet or more in length, and are pegmatitic in character, frequently carrying much plagioclase feldspar—a mineral which is only occasionally present in the "Sulphur" vein. No openings have been made much below water level, but where the lenses have been mined their dip is practically vertical.

While the veins and country rock at the Young American mine are much broken by jointing, and there is in places a small amount of faulting along these joints, there is no evidence of important faulting since the formation of the veins. The irregularities in the strike and dip which were mentioned above are believed to be due to faulting and fracturing prior to the formation of the veins, which left openings or lines of weakness along which the solutions that deposited the ores were able to penetrate.

In addition to the veins described above, several quartz veins carrying considerable tourmaline outcrop in the vicinity of the mine, but at the surface they contain only traces of gold and therefore practically no development work has been done on them.

Detailed descriptions of the veins and wall rock.—At the bottom of the incline from the "Sulphur" shaft, about 100 feet from the surface and 65 to 75 feet below the natural water level, the vein consists of lenses and irregular masses of quartz distributed over a belt 5 to 6 feet in width, which is here confined to the bed of light-colored gneiss. A sketch, drawn to scale,

showing the distribution of vein quartz and the structural relations of the wall rock, is given in fig. 6. Only a short distance above this point the quartz begins to collect together so as to form a single well-defined and continuous vein.

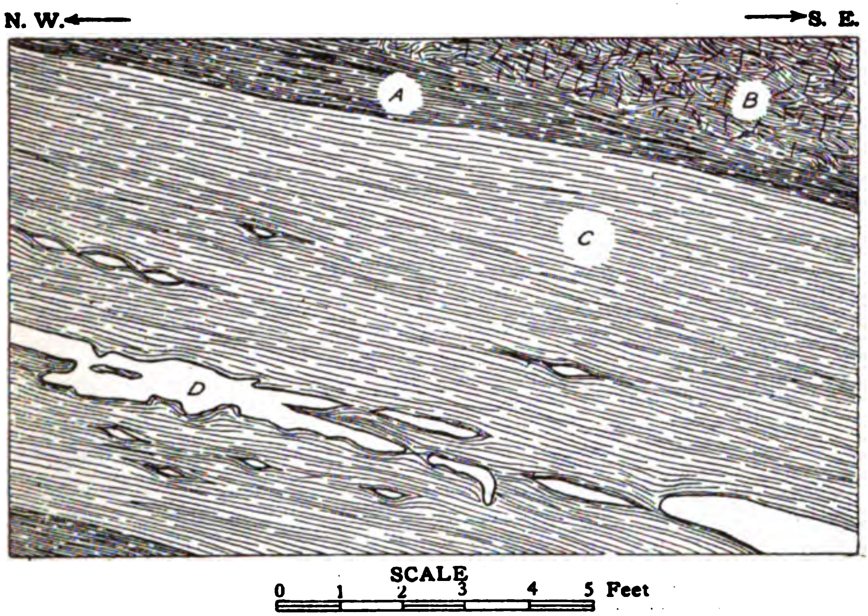

Fig. 6.—Vertical section showing vein at bottom of "Sulphur" incline, Young American Mine. ***A*, dark-colored gneiss; *B*, partly decomposed gneiss; *C*, light-colored gneiss; *D*, vein quartz.**

The vein quartz is white, translucent and coarsely crystalline. It contains a little over 1 per cent. of pyrite, slightly cupriferous and sometimes associated with fine-grained magnetite, and, rarely, crystals of white feldspar difficult to distinguish from quartz are present. In places there are small masses of chlorite and flakes of biotite which probably represent altered inclusions of country rock. A carefully collected, average sample assayed $1.34 in gold with no silver. In the vicinity of the quartz masses, the gneiss is also mineralized to a considerable degree, containing disseminated grains of pyrite and many small veinlets of quartz which decrease in number and size on passing away from the vein stringers, so that they are not noticeable at a distance of 4 or 5 feet. These veinlets range from half an inch down to those that are microscopic in size and usually

parallel the schistosity; the pyrite occurs in small grains and elongated masses less than 1 cm. in diameter and is frequently more plentiful along the quartz veinlets.

The dark-colored gneiss overlying the bed of lighter color, while apparently fresh near the contact, passes gradually into partially decomposed rock a short distance above (see fig. 6), and this illustrates the great depth to which weathering has reached in this area. As this was the deepest opening accessible in the area when the region was studied by the writer, average samples of the different rocks exposed at this point were carefully taken. A partial analysis of the vein quartz was made, and complete analyses of the two varieties of gneiss and also of the partly decomposed gneiss. For convenience in comparison these analyses are assembled in the table given below, which is followed by a detailed petrographic description of the rocks. The analyses are arranged in the order of their relative distance from the vein quartz, which is also the order of decreasing mineralization as is indicated by the decreasing percentages of SiO_2 and FeS_2.

Analyses of vein and wall rock from the Young American Gold Mine.

	I	II	III	IV
SiO_2	.....	75.72	66.69	63.68
Al_2O_3	.....	13.14	15.25	16.11
Fe_2O_3	.....	0.33	1.46	4.05
FeO	.....	1.44	3.78	2.67
MgO	.....	0.31	2.89	3.55
CaO	.....	1.07	2.33	2.18
Na_2O	.....	3.77	3.56	3.75
K_2O	.....	1.75	1.65	1.43
H_2O-	.....	0.12	0.33	1.07
H_2O+	.....	1.00	1.26	0.96
TiO_2	.....	0.10	0.41	0.46
ZrO_2	.....	0.01	.....	.....
CO_2	.....	0.63	0.36	.....
P_2O_5	.....	0.04	0.06	0.06
S	.....	.....	.....	Trace
Cr_2O_3	.....	.....	.....	0.01
V_2O_3	.....	.....	.....	0.01
MnO	.....	0.02	0.09	0.08
BaO	.....	0.02	.....	.....
Li_2O	.....	Trace	Trace	Trace
Cu	Trace	Trace	Trace	Trace
FeS_2	1.13	0.62	0.09	Trace
Gold (ounces)	0.065	Trace	Trace	Trace
Silver (ounces)	.....	Trace	.....	.....
		99.99	100.21	100.07

I. Vein quartz (*D* in fig. 6). This sample contained 0.87 per cent. iron in excess of the amount necessary to form pyrite, the excess being present as a constituent of magnetite and chlorite. Determinations made by E. E. Burlingame and Co.

II. Light-colored gneiss (*C* in fig. 6). Analysis made by Roger C. Wells; gold and silver determined by E. E. Burlingame and Co. Another sample of this rock assayed by the writer gave 0.05 oz. of gold per ton.

III. Dark-colored gneiss (*A* in fig. 6). Analysis made by Roger C. Wells; gold and silver determined by the writer.

IV. Decomposed dark-colored gneiss (*B* in fig. 6). Analysis made by Roger C. Wells; gold and silver determined by the writer.

The dark-colored gneiss is gray, and in places has a slightly greenish tinge. It is fine-grained, even-granular, and the minerals are imperfectly segregated into parallel bands 1 mm. or less in width, which are frequently folded or contorted to a small extent. The dark bands are due to the presence of biotite, chlorite, hornblende, and magnetite; the light bands are composed chiefly of quartz with a little sericite. Pink garnets, about 2 mm. in diameter, more or less crushed and elongated parallel to the schistosity, occur scattered through the rock, and a little pyrite may also be distinguished.

Examined microscopically, the rock (Spec. 112-A) has a well-defined schistose structure, the different minerals being oriented parallel to their greatest elongation, and largely segregated into bands which differ from one another in size of grain as well as in mineral composition. In the order of relative abundance the minerals present in the slide are quartz, feldspar, biotite, chlorite, hornblende, magnetite, carbonate (calcite ?), pyrite, and sericite. The quartz grains are usually clear, show no optical distortion, and contain occasional rutile needles, and other minute inclusions. Some of the larger bands consist almost exclusively of quartz, the individual grains of which they are composed being slightly larger than those in the rest of the rock. These bands are probably chiefly due to the recrystallization of silica originally present in the rock, but may be formed in part from quartz brought in by the vein-forming solutions. Much feldspar (probably oligoclase) is present in the slide. It is partly kaolinized, seldom shows twinning, and, as the index of refraction is practically the same as quartz, is hard to distinguish from the latter. The biotite is light brown to greenish-brown in color, strongly pleochroic, and frequently shows partial alteration to chlorite. There is much chlorite present, occasionally showing multiple twinning, and it appears to have been derived chiefly from the hornblende. Hornblende occurs in two varieties; one light green in color, the other light brown to nearly colorless. It is extensively altered with the formation of carbonate (calcite ?) and chlorite. In places numerous fragments of hornblende occur,

separated and completely surrounded by calcite, which extinguish simultaneously under crossed nicols, showing that all of the fragments belong to a single crystal which has undergone partial alteration. Much fine-grained magnetite is present and occasionally a little pyrite.

In the chemical analysis, the excess of magnesium over calcium indicates that the rock is sedimentary in origin, and this is confirmed by the structural relations. Chemical analysis as well as microscopic examination shows that weathering has begun to affect the rock even where freshest. In comparing the analysis of the freshest material with that of the partly decomposed rock, it is seen that the chief changes, aside from kaolinization of the feldspars, have been the removal of carbonate and the oxidation of much of the ferrous iron to the ferric condition.

As the light-colored gneiss at this point is nearer to the quartz stringers than the darker gneiss, it contains more quartz veinlets and a larger amount of pyrite. The rock (Spec. 112-C) is white to light gray in color, and distinctly banded, though this feature is not as noticeable as in the darker gneiss, because of the lack of contrast in the colors of the principal constituents—quartz, sericite, and feldspar. The bands are frequently contorted, especially in the vicinity of the quartz stringers and lenses. The small veinlets of quartz, ranging up to about 1 cm. in diameter, are usually parallel to the banding, but in places cut directly across. Pyrite occurs in grains and small lenticular masses elongated parallel to the schistosity, is sometimes associated with magnetite, and is more plentiful in the vicinity of the quartz veinlets. A little chlorite, occasional pink garnets, crushed and elongated parallel to the schistosity, and very rarely needles of black hornblende, make up the minor constituents which are recognizable in the hand specimen.

Microscopic study shows that the principal mineral constituents in the order of their relative abundance are quartz, sericite, feldspar, chlorite, and carbonate (calcite ?). The textural characteristics and mineral composition of the rock are similar to the darker gneiss (112-A) excepting that quartz and sericite are more abundant, while biotite and hornblende are essentially absent. The minerals, particularly sericite, are largely segregated into parallel bands. The feldspars are not so extensively kaolinized as in the overlying rock, but appear to be similar in composition. They are seldom striated and have an index of refraction only a little below quartz, indicating that they are probably near albite-oligoclase in composition. Orthoclase is rare if present, and probably most if not all of the potash content is in the form of sericite. An analysis of this rock is given in column II of the table on page 124.

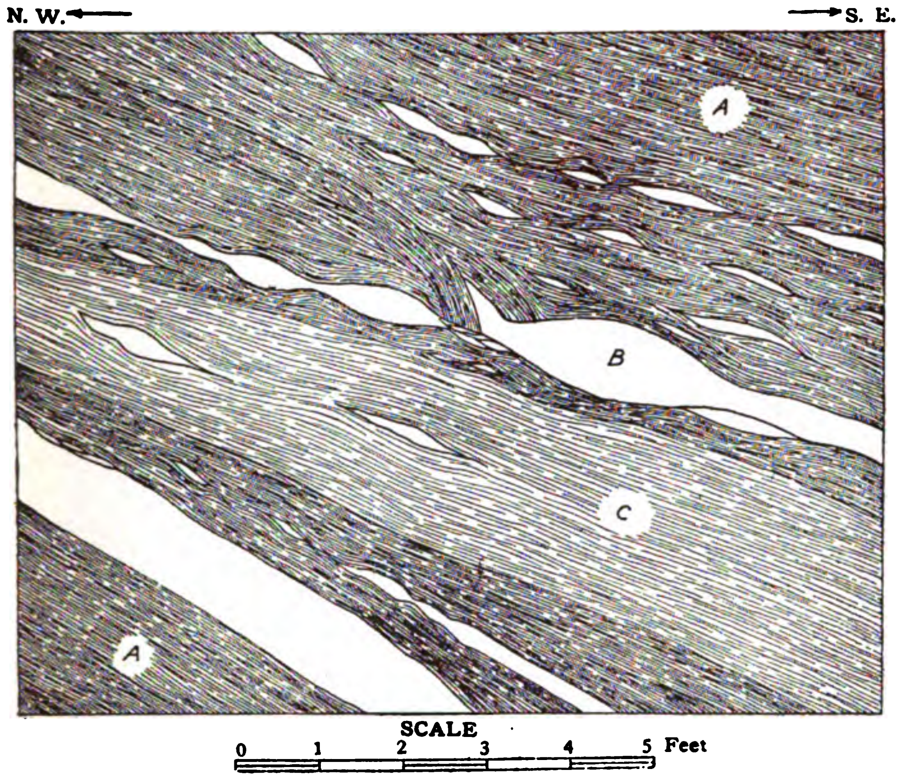

Fig. 7.—Sketch showing distribution of vein quartz in light- and dark-colored gneisses at the Young American Mine. *A*, dark-colored gneiss; *B*, vein quartz; *C*, light-colored gneiss.

The sketch shown in fig. 7 indicates the appearance of the face in the drive running southeast near the bottom of the "Sulphur" incline. The location is about 10 feet above the sketch shown in fig. 6, and 18 feet southeast. Here the bed of light-colored gneiss is thinner, and the vein quartz chiefly distributed in the overlying and underlying gneiss. The quartz vein, about a foot wide, shown in the lower left hand corner of the sketch, contains chalcopyrite as well as pyrite. Mr. Knutzen, Superintendent of the Young American mine, states that samples from this 1-foot vein yielded from $11.20 to $24.00 gold per ton, and that a picked specimen showing chalcopyrite carried $50.00 per ton. The value of the ore in this drive seems to vary greatly within short distances; an average sample, obtained from 6 buckets (about 1½ tons) after passing through the crusher, assayed $8.00, while a similar sample from 4 buckets of ore

that were obtained as a result of the next round of blasting gave only $1.00 per ton. According to Mr. Knutzen the gold content is highest where chalcopyrite is found.

A hand specimen (116) was obtained from this drive showing the two varieties of gneiss in contact. The line of contact is quite sharp and is parallel to the banding which is slightly contorted. The rock is cut by narrow veinlets of quartz commonly parallel to the banding and in places showing a tendency to follow the contact between the light and dark gneiss, but which frequently cut directly across the schistosity. A thin section was made to show one of these veinlets about 0.5 cm. in width. Under the microscope, numerous liquid- and gas-filled cavities can be seen in the quartz, usually arranged in rows or planes that occasionally pass without interruption from one crystal individual to another. Some of the cavities contain bubbles in constant and rapid vibration. The dark variety of gneiss, which in the slide forms the walls of the veinlet, is similar to that described above. The constituent minerals are quartz, feldspar, biotite, hornblende, chlorite, sericite, and calcite, and a little pyrite, magnetite, and ilmenite partly altered to leucoxene. A small colorless garnet, showing slight anomalous biaxial character, is also present in the slide. In several places pyrite occurs, bordered by a narrow rim of magnetite, which was probably produced under conditions of partial oxidation.

The smaller veinlets, especially in the light-colored gneiss, show a strong tendency to form lenses, but they are not as perfectly developed as those in the "Middle" vein at the Tellurium mine. A photograph of some small lenses in light-colored gneiss from the "Sulphur" shaft is shown in Pl. X, fig. 2.

Pyrite is more plentiful in the light-colored gneiss than in the dark variety, and occurs in elongated grains or broken lines parallel to the banding. Some secondary pyrite was noted along joint planes in both the vein quartz and the country rock.

Near the bottom of the "Sulphur" shaft, about 80 feet from the surface and just above the incline, the quartz vein is 2 feet wide, and the dark gray, biotite-sericite gneiss, which forms the foot wall, is heavily impregnated with pyrite and contains occasional lenses and veinlets of quartz. Mr. Knutzen obtained assays of $3.60 gold per ton from this mineralized wall rock, which extends several feet from the vein.

In Pl. X, fig. 1, is shown a photograph of one of the quartz veinlets in contact with the heavily mineralized gneiss. A crystal of light blue cyanite 6 mm. wide and 3 cm. long extends from the wall rock out into

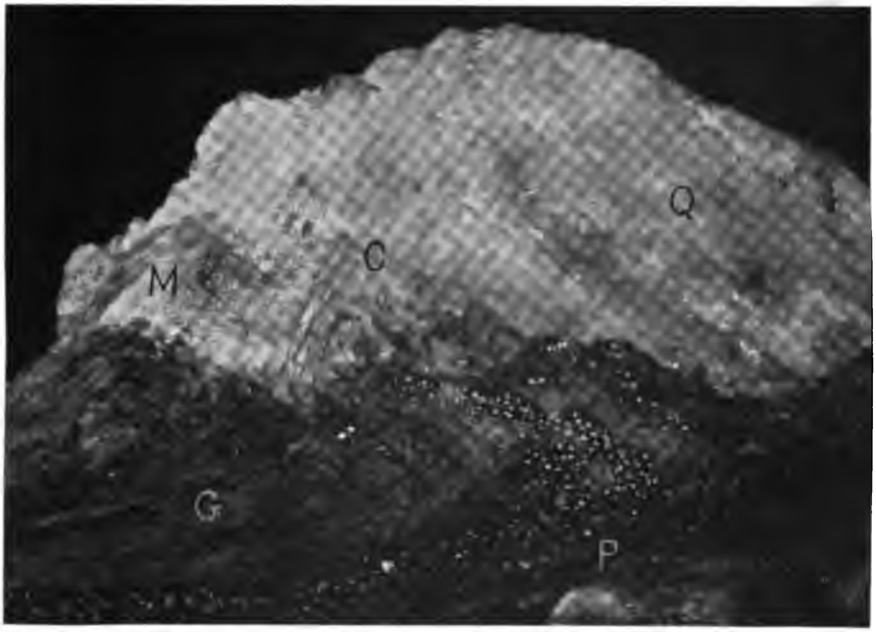

Fig. 1.—Photograph showing cyanite and muscovite in vein quartz from the Young American mine. *C*, cyanite; *M*, muscovite; *Q*, vein quartz; *P*, pyrite; *G*, gneiss.

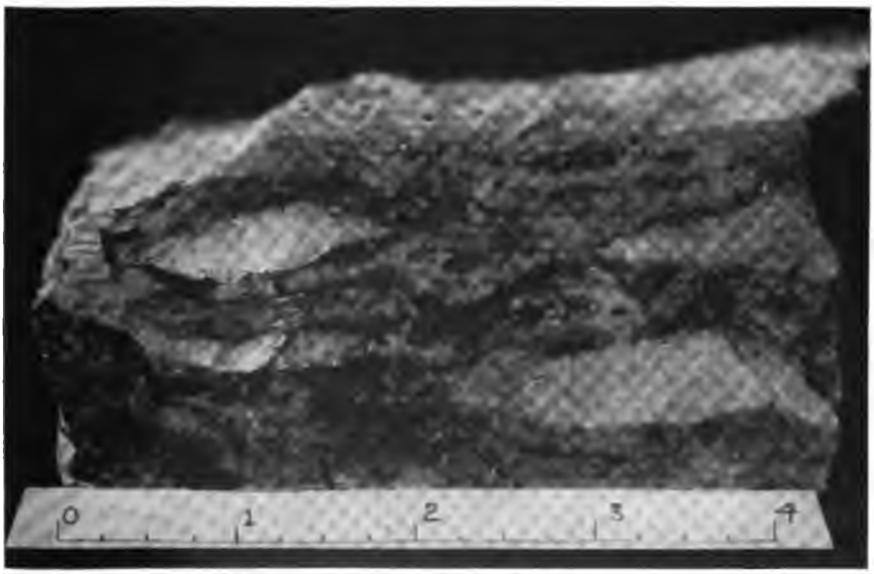

Fig. 2.—Lenses of vein quartz in gneiss from Young American mine.

CYANITE AND MUSCOVITE IN QUARTZ, AND QUARTZ LENSES IN GNEISS.

the quartz. The vein quartz also contains a little white feldspar, flakes of muscovite, and a few specks of chlorite. Calcite occurs in the gneiss and is partly concentrated along the contact with the veinlet. Very little pyrite is present in the quartz, but it is abundant in the gneiss, where it occurs in bands and broken lines parallel to the schistosity, which is much folded in the vicinity of the veinlet. Pieces of vein quartz, similar to that just described, but containing both cyanite and tourmaline, were found on the surface. The cyanite is sparingly distributed through the quartz in light blue prismatic crystals 3 to 4 mm. wide and 1.5 cm. long; and the tourmaline occurs in black prisms 2 to 3 mm. in diameter, which usually radiate in all directions from a common center. Elsewhere cyanite was noted in the metamorphosed wall rock near the veins, but in the specimens described above it occurs in detached prisms within the vein quartz itself.

In the foot-wall, 5 or 6 feet from the vein at the bottom of the "Sulphur" shaft, the rock is a dark gray, fine-grained, even-granular gneiss, with well-marked banding. It shows no evidence of mineralization, pyrite as well as the quartz veinlets being absent. The light-colored bands in the rock range up to 2 mm. in width and are composed chiefly of feldspar and quartz, though they are not as a rule distinguishable from each other in the hand specimen. The dark bands are narrower and consist essentially of biotite, hornblende, and chlorite. Much magnetite is present in small grains, but no garnets were noted. Under the microscope the rock is similar to the dark variety of gneiss described on pages 125-126, except that feldspar seems to be dominant over quartz, possibly because of the absence of silicification by vein-forming solutions. In the order of their relative abundance the minerals present are feldspar (probably andesine or oligoclase-andesine), quartz, hornblende, biotite, chlorite, calcite, and magnetite, with a few scattered grains of zircon and titanite. The hornblende occurs in two varieties, one green in color, and the other yellowish-brown. The latter, which is subordinate in amount, has parallel extinction and is present in long ragged prisms. It is one of the orthorhombic amphiboles. The other minerals present no unusual characteristics.

The drive connecting the "Sulphur" and "H. V." shafts exposes an offset of 10 to 15 feet in the course of the vein just north of the "Sulphur" shaft, the space between being occupied by a zone containing numerous lenses and irregular masses of quartz. At the shaft the vein is standing nearly vertical. The sketch given in fig. 8 shows the distribution and shape of the quartz masses exposed on the east side of the drive about 15 feet north of the shaft. The country rock here is the dark variety of gneiss, and is much folded and contorted.

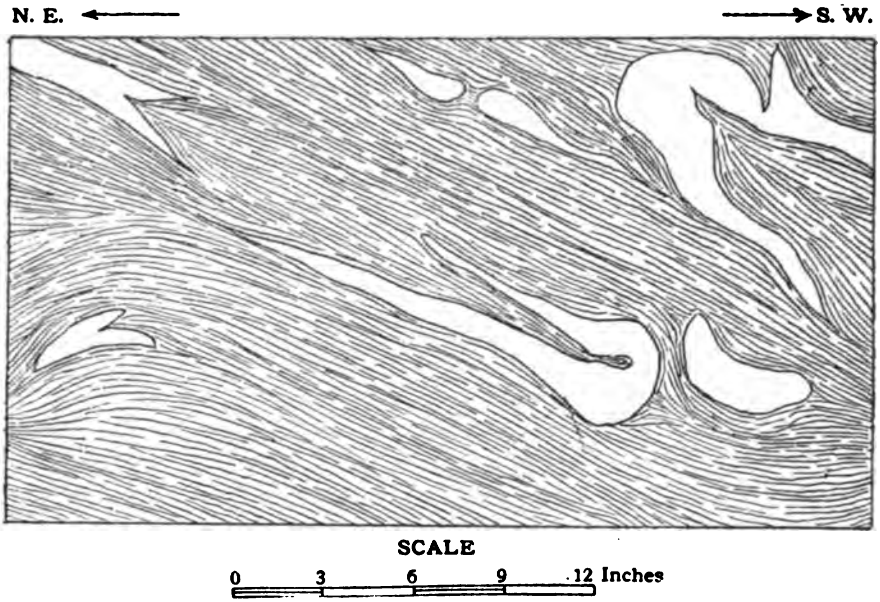

Fig. 8.—Vertical section showing distribution of vein quartz in a sheared zone at the Young American Mine.

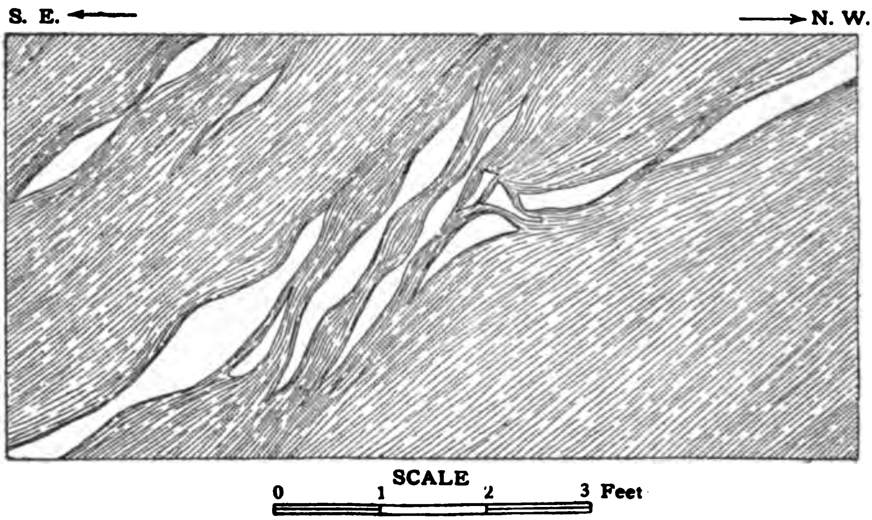

Fig. 9.—Sketch showing distribution of quartz lenses in a zone of shear faulting, Young American Mine.

There is another sharp break in the course of the vein near the Chittenden shaft where the strike suddenly changes from N. 21° to 53° E., and at this point there is a similar breaking up of the vein into separate lenses and irregular masses. A sketch of the vein, exposed in a small opening opposite the Chittenden shaft, is given in fig. 9. The distribution of the quartz lenses relative to the average strike and dip of the vein suggests that they were formed in a zone of shear faulting. The country rock is the dark variety of gneiss which is slightly mineralized in the immediate vicinity of the vein. A sample from the hanging wall, assayed by the writer, gave 0.03 ounces gold per ton. A 12-ton mill run of mineralized gneiss from the foot-wall of the vein, in the main drive about 40 feet northeast of this place, is said to have averaged $3.60 gold per ton.

In the "H. V." shaft, the vein is nearly vertical to a depth of 30 feet, at which point it begins to dip toward the southeast and leaves the shaft. (See fig. 10.) Where the vein is exposed by the cross-cut from the shaft, 54 feet below the surface, it is 3 to 6 feet in width, dips at an angle of 40° toward the southeast and has a strike of about N. 30° E. The wall rock on both sides of the vein is the dark variety of gneiss, much decomposed, and showing no evidence of mineralization, but Mr. Knutzen states that a sample from the hanging wall assayed $0.50 per ton. The vein quartz is irregularly mineralized, containing pyrite, chalcopyrite, and occasionally a very little sphalerite.

The sulphides are strung out in narrow lines or small lenticular masses approximately parallel to the walls, and the sphalerite usually occurs separate from the other ore minerals instead of being intermixed with them. A little white feldspar occurs in some of the quartz, but appears to be chiefly confined to the border portions of the vein. Very rarely, black tourmaline is present in small radiating prisms, and one specimen was found with a speck of free gold about 0.4 mm. in diameter, resting on the tourmaline, which is imbedded in quartz and surrounded by a small amount of limonite derived from pyrite. Pieces of the vein frequently show imperfect crystals of quartz lining joint planes, and several small vug-like openings were seen in which the walls were lined in a similar manner. It is probable, however, that these openings are due to the oxidation and removal of pyrite rather than to spaces that were left unfilled when the vein was originally formed. Some of these vug-like spaces contain a little pyrite, more or less oxidized, and in places the sulphide has a crystal form closely resembling marcasite. Small flakes of chlorite and muscovite occur in parts of the vein.

The gold is not evenly distributed throughout the vein, much of it being apparently concentrated in the sulphides. Mr. Knutzen obtained an assay of 5.8 ounces of gold per ton from a piece of the chalcopyrite. A mill run made on 8 tons of ore from the vein at this point averaged $3.20 per ton.

The "H. V." shaft passes through the bed of light-colored gneiss about 15 feet below the cross-cut to the vein. At this point it is 3 to 4 feet thick and dips towards the southeast at an angle of about 25° (see fig. 10). The rock is white and highly lustrous on fracture surfaces parallel to the cleavage. In addition to the quartz and sericite, a little fine-grained pyrite and rarely small needle-like prisms of hornblende are sparingly scattered through the rock. In thin section (Spec. 506) under the microscope, the rock shows distinct banding due to the partial localization of sericite in narrow parallel bands. Quartz, the dominant mineral, occurs in small rounded grains associated with feldspar (albite ?), which is usually clear and unstriated, though mutiple twinning may be seen in places. Small cubes of pyrite and a very little chlorite make up the accessory minerals.

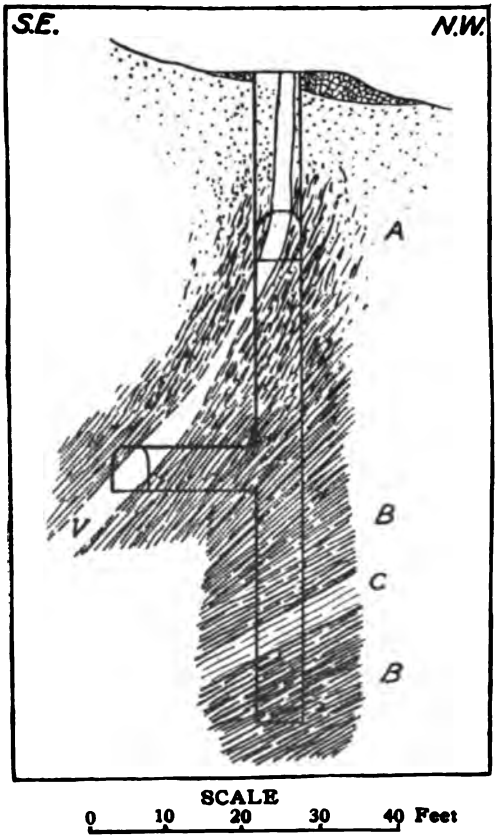

Fig. 10.—Vertical section through "H. V." shaft, Young American Mine. *V*, vein; *A*, decomposed gneiss; *B*, dark-colored gneiss; *C*, light-colored gneiss.

The rock exposed in the bottom of the shaft is a dark greenish-gray gneiss in which the banding is only imperfectly developed. In thin section (Spec. 503), the minerals identified in order of their abundance were hornblende, feldspar, quartz, biotite, chlorite, magnetite, and a little carbonate. The hornblende is light green in color

and has rather low interference colors. The cleavage is good but the crystals are irregular in outline and contain occasional inclusions of the other minerals. Alteration to chlorite is frequently shown. Part of the feldspar is twinned after the albite law, but much of it is unstriated and difficult to distinguish from quartz, which it closely resembles in refraction and birefringence. The biotite is light brown in color and strongly pleochroic. Angular grains of magnetite are scattered through the slide and a little carbonate is present.

The small amount of carbonate contained in the gneiss just described, and its absence in the light-colored variety from the "H. V." shaft, is in marked contrast to its abundance in specimens from other parts of the mine. The relative scarcity of carbonate in these rocks may be due to greater depth below water level—75 or 80 feet—or possibly it is to be explained by distance from the vein—about 25 or 30 feet.

In the southwest end of the mine near the "12th of May" shaft the vein is 2 inches to 3 feet wide and averages about 14 inches. For some distance it splits up into two separate stringers which in places are slightly contorted. Slickensides were noted in a number of localities, but the vein is little affected by faulting. Radiating prisms of black tourmaline are of rare occurrence, being found occasionally in quartz from near the shaft. Most of the wall rock in this portion of the mine shows much decomposition, but in the floor of the drive 125 feet southwest of the "Sulphur" shaft there is a little fresh gneiss exposed on the foot-wall side of the vein. The rock (Spec. 118) is white to light greenish-gray in color where fresh, but along joint planes it is stained brown from the alteration of iron minerals, and in places the stain extends several inches from the fracture surface. Quartz and feldspar are the chief minerals with chlorite, hornblende, calcite, biotite, cyanite, and sericite present in smaller quantity. Cubes and irregular grains of pyrite are sparingly disseminated through the rock, and upon assaying an average sample it yielded 0.01 ounce of gold per ton.

Examination under the microscope shows that part of the quartz is present in small veinlets, probably as a result of mineralization by the vein-forming solutions. Part of the feldspar shows albite twinning, and is unquestionably acid plagioclase, but in most cases the twinning is absent and identification could not be made with certainty. There probably is some orthoclase present, but most of the unstriated feldspar is plagioclase. There are large areas in the thin section consisting of intercrystallized calcite and chlorite, possibly derived from hornblende, but some of the chlorite

was clearly formed from biotite. Areas of fine scaly sericite are present, some of which contain nuclei of unaltered mineral—probably cyanite.

The ore seems to occur in shoots that dip steeply toward the left as they descend along the vein, but this can not be verified until more development work has been done. One such ore shoot was found near the "Sulphur" shaft, and another between the "H. V." and the Chittenden shafts.

In the adits that were driven under the hill toward the "House" vein most of the country rock is soft and decomposed, but at several places where the floor of an adit approaches water level, fresh rock is encountered. Both the fresh exposures and the residual decay indicate that the rock is normally a hornblendic gneiss or schist, essentially the same as the dark variety of gneiss found in the underground workings on the "Sulphur" vein. In the immediate vicinity of the numerous veinlets and lenses which are exposed in the adits and have been worked to a limited extent for gold, the country rock exhibits certain important variations from the normal, which later will be described in detail.

The country rock, exposed near the portal of a prospecting tunnel that was started on the northwest side of the hill, is almost massive in the hand specimen (502), but shows a distinctly schistose structure under the microscope. Megascopically it is a dark greenish-gray, fine-grained rock, containing numerous idiomorphic garnets 1 to 2 mm. in diameter, and occasional rare grains of pyrite. The constituent minerals are amphibole, quartz, soda-lime feldspar, chlorite, magnetite, carbonate, a very little greenish-brown biotite, and quartz. In thin section most of the amphibole is green to bluish-green in color, and probably corresponds to common hornblende, but there are two other varieties present in small amounts. One is pleochroic in shades of light pink and dark greenish-gray, the interference colors being blues and greens of the second order, and is monoclinic in crystallization; the other is light yellowish-brown in color and orthorhombic in its crystallization. The latter mineral is present in much of the gneiss in this vicinity, but always in very small quantity. Hornblende is dominant over the other minerals and usually shows parallel orientation. Some of the feldspar (andesine) shows albite twinning, but much of it is unstriated and difficult to distinguish from quartz, which it resembles in refraction and birefringence. Much of the chlorite shows multiple twinning.

The veinlets and lenses vary from a fraction of an inch in thickness up to masses 2 feet wide and 25 feet or more in length. The shape of some

of the old openings suggests that even larger lenses may have been removed by previous mining operations. The veinlets are exposed in the adits on both sides of the hill, but are more plentiful in those that were driven from the west side. The larger lenses consist essentially of quartz, with pyrite and a little feldspar, the latter being chiefly concentrated near the walls though also occurring throughout the mass. In some of the smaller veinlets feldspar in places is dominant over quartz. Along fractures in the quartz-feldspar rock, much white mica is found in flakes 6 or 7 mm. in diameter with no regular orientation. While these crystals are quite large and may be primary muscovite, their localization along fractures indicates that they are probably secondary, derived from feldspar. Pyrite is very unequally distributed, occurring locally in masses several inches across, while elsewhere it is present in small quantity only. The larger masses seen were extensively altered to limonite.

Gold occurs in the native state both in the quartz and in pyrite, and there may also be a little telluride of gold present since tellurium has been detected in the ore. Mr. Knutzen states that the ore seems to be richest in gold near the walls of the lenses. The average value of 76¾ tons of ore obtained from these lenses and veinlets was $4.10. Small grains of visible gold ranging up to 1 mm. and over in diameter are occasionally seen.

A piece of quartz, obtained from one of the lenses, contains embedded in it a grain of gold, averaging about 0.75 mm. in diameter, which is in contact with a minute speck of some soft cleavable mineral with metallic luster—probably tetradymite or sylvanite. Only 3 mm. distant from the gold, there is a cavity in the quartz, roughly cubical in shape, and about 1.5 mm. in diameter, which was filled with tetradymite, and in the latter a small crystal of pyrite was embedded. Part of the tetradymite was removed and tested for identification. It is tin-white in color, has a high metallic luster, perfect basal cleavage with flexible laminæ, and is quite soft, readily marking paper. Heated before the blowpipe it fuses easily and gives an orange-yellow sublimate. Upon gently heating with sulphuric acid in a test tube the acid assumes the beautiful reddish-violet color distinctive of tellurium. The same specimen of quartz contains a little kaolinized feldspar and some dark brown limonite derived from pyrite.

A thin section (Spec. 498) from one of the quartz-feldspar veinlets was examined under the microscope. The quartz individuals range up to 3 mm. in diameter, contain numerous irregular gas- and fluid-filled cavities, usually arranged in long rows, and show slight wavy extinction, but no granulation or other evidence of crushing. The feldspars range up to

1 cm. or more in diameter, and are easily distinguished from quartz because of a slight cloudiness due to partial alteration. Multiple twinning after the albite law is sometimes though not always present. The average index of refraction is a little less than that of quartz, and this together with the extinction angle indicates a composition of approximately Ab_2An_1 (oligoclase-andesine).[a] A little sericite occurs in places, usually in clusters of curved and radiating scales. The only other minerals noted in the slide were a few grains of ilmenite and its alteration product leucoxene.

The larger lenses appear to be parallel to the strike and dip of the country rock, but many of the veinlets cut directly across. In places, as shown in fig. 11, small irregular veinlets and lenses run in every conceivable direction. Where stringers of quartz and feldspar cut across the cleavage of the gneiss, smaller veinlets branch off at short intervals and run parallel to the schistosity, giving rise to a banded rock which is very striking in appearance.

Specimens of this rock consist of alternating bands of light and dark minerals, ranging up to 1.5 cm. in width, which widen here and narrow there, and frequently pinch out entirely. Some of the light-colored bands are composed essentially of quartz and feldspar, while others consist largely of sericite; and the dark-colored bands are composed chiefly of dark green hornblende, with sulphides of iron and magnetite abundant in places. The quartz-feldspar bands resemble veinlets, and when the rock is fresh it is difficult to distinguish between the two component minerals, as they are both white. The rock breaks most readily along the sericite bands and there presents a light gray surface on which long, narrow, glistening streaks of sericite are plentifully sprinkled. These streaks of sericite average about 2 mm. in width and range up to 2 or 3 cm. in length. On some of the specimens a little light blue cyanite can be distinguished, and the sericite streaks are probably due to the alteration of that mineral. The dark-colored bands when narrow consist of dark green hornblende with a sprinkling of magnetite, but some of the wider bands have a narrow border of coarsely crystalline hornblende 2 to 3 mm. wide along their contacts with the quartz-feldspar veinlets, while their central portions are filled with a fine-grained mixture of carbonate, hornblende, pyrrhotite, pyrite, and magnetite.

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[a] A specimen of this feldspar was submitted to Dr. E. S. Larsen, Jr., for accurate determination of the maximum and minimum indices of refraction by the immersion method. His report is as follows: "Oligoclase to andesine. Dominantly andesine or oligoclase-andesine.

$$\alpha = 1.539 \pm 0.003 \text{ to } 1.544 \pm 0.003$$
$$\gamma = 1.546 \pm 0.003 \text{ to } 1.553 \pm 0.003$$

Extinction on the rhombic section 12½° andesine."

Fig. 11.—Sketch showing distribution of vein quartz, Young American mine.

The size of the hornblende crystals seems to vary somewhat with the width of the veinlets with which they are in contact, and along some of the larger veinlets they are 1 cm. in diameter, while prismatic crystals of tremolite, which is also present, measure as much as 2

cm. in length. Tremolite is frequently abundant near the quartz-feldspar stringers, sometimes being roughly segregated into bands, but does not appear to be an important constituent in the normal country rock. Occasionally elongated grains of a light brown mineral may be seen, which under the microscope were identified as orthorhombic amphibole.

Microscopic examination of thin sections (Specs. 499, 500, and 501) shows that the principal minerals have undergone extensive alteration, and it is not always possible to say just how much of this was due to the injection of the quartz-feldspar veins and how much is due to weathering. The hornblende is pleochroic in shades of light green, blue, and brown, and has low interference colors. The tremolite is colorless and shows rather high interference colors. In both varieties of amphibole, but especially in the hornblende, cleavage is well developed; both are ragged in outline and frequently show micropoikilitic texture; and each contains occasional inclusions of the other. Both show extensive alteration to carbonates, and chlorite, probably derived from hornblende, is also present. The carbonates in places contain small irregular fragments of amphibole, which, on rotating the stage, extinguish together, indicating that they belong to a single crystal individual. In addition to the monoclinic amphiboles there is a small amount of light yellowish-brown orthorhombic amphibole present. It occurs in elongated crystals with poor cleavage and ragged outlines which only rarely show straight prismatic boundaries. Extinction is parallel to the elongation and the refraction and birefringence are moderate. Quartz occurs in clear irregular anhedra which sometimes contain numerous liquid and gas inclusions. The feldspars usually show fine albite twinning, and some are also twinned according to the pericline law, while others show no visible striations. The index of refraction averages about the same or slightly higher than quartz, indicating that they are chiefly andesine or oligoclase-andesine. Orthoclase is rare if present, and has probably been entirely altered to sericite. Some of the feldspars show alteration to calcite. Sericite is rare except in light-colored bands which are composed almost exclusively of this mineral. It occurs in long flakes or scales which usually show good cleavage, and is secondary after both cyanite and feldspar. In places a little unaltered cyanite can be distinguished in the slides, but it has almost entirely gone over to sericite. The iron ores—pyrrhotite, pyrite, and magnetite—are plentifully distributed throughout the slide, but are more abundant in the areas of dark-colored minerals. The magnetite is frequently idiomorphic, and the sulphides in places surround the magnetite. A little biotite, light

brown to greenish-brown in color, is occasionally present in small disseminated flakes.

In the partly decomposed gneiss exposed by the adits, there are numerous slickensided surfaces stained black with manganese, probably in the form of wad. Some of these surfaces are very large, covering an area of at least several square yards. As a rule they conform in strike and dip to the schistosity of the formation, and they are common along the walls of the quartz veins. Similar slickensided surfaces occur in the workings on the "Sulphur" vein, but they were not found in the lower openings where the rock is unaltered by weathering. Because of their localization in the weathered material it is believed that these slickensides are due to changes in volume resulting from decómposition.

The Belzoro Mine.

Location.—The Belzoro mine, consisting of about 374 acres, is located 6 miles northeast of Columbia and three-quarters of a mile north of Lantana. The veins on this tract evidently belong to the same system as the "House" vein on the property of the Young American mine (see pp. 134-139), which adjoins the Belzoro on the northeast.

History.—Mr. Hamilton states that "the antiquity of the Belzoro mine is evident from the fact that crucibles, made by the Indians, or perhaps some remoter and unknown tribes, have been found on it, bearing a rude resemblance to an acorn cup, and manifestly devoted to the use of melting the precious metals,"[a] but in this belief he is probably mistaken. No articles of Indian manufacture made from gold have been found in Virginia, and students of the North American Indian are generally agreed that he was ignorant of the art of melting metals. The so-called crucibles were probably used for some other purpose and doubtless were brought from the Indian soapstone quarries 3 miles northeast of this property, which are described on pages 170-171.

Gold was discovered on the Belzoro tract by surface washing in 1832, at which time the property belonged to Mr. William Southworth. The placer gravels are said to have been very productive, $30,000 having been recovered from a limited section known as "Dry Gulch."[b] Bed rock was 1 to 6 feet below the surface and many nuggets weighing from 4 to 7 pennyweights were found.[c] The work of washing gold from the gravels con-

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[a]Hamilton, J. R., The Natural Wealth of Virginia, *Harper's Magazine*, 1865, vol. xxxii, pp. 32-42.
[b]Snell, P. A., From a report on the Belzora mine.
[c]Hamilton, J. R., Op. cit.

tinued with varying success up to 1849, when the property was sold to Mr. Geo. Fisher.

Several shafts were sunk to depths 30 to 60 feet and many surface cuts and pits were opened. A 10-stamp mill was built to treat the ores which are said to have yielded as high as $300.00 per day, but all mining operations were interrupted by the Civil War. After the close of the war a little work was done from time to time, but the mine has remained idle since the mill burned some years ago.

Descriptive geology.—There are no outcrops on the property and very little float rock aside from vein quartz can be found. The old workings have caved and are now inaccessible, but information obtained elsewhere in the vicinity confirms the data collected on the property and indicates that the country rock consists of a series of quartzose gneisses and schists varying somewhat in composition. A number of large pieces of float were found near the branch where it is crossed by the road a short distance northeast of the house. This rock is a light gray, slightly banded gneiss composed for the most part of quartz, white mica and feldspar, with a little dark mica and magnetite. A detailed petrographic description is given on page 39. While the rock was not found in place at this point it does outcrop beyond the limits of the property in both directions along the strike and is probably the dominant rock type in this vicinity. The ferruginous quartzite found on the Webb place (see pp. 19-20) also continues on this property. The veins are said to be enclosed in light-colored quartz-sericite schists (the talcose slate described by some of the early writers).

According to P. A. Snell there are two well-defined veins on the property 300 yards apart, one averaging from 2 to 3 feet in width, and the other from 3 to 4 feet, while the course of both is northeast and southwest and the dip 45° toward the southeast, approximately parallel to the strike of the country rock. The two principal veins are paralleled by a large number of flat lens-like ore-bodies varying from 1 to 6 inches in width which are not continuous for any great distance, but pinch out and start in again a little to one side or farther along the strike.[a]

The ore is described as quartz carrying iron pyrite which is largely oxidized near the surface, and on either side of the veins there is said to be a narrow selvage of clay and grit (probably kaolin from the decomposition of feldspar), which is quite rich in gold, the latter showing plainly

[a]Snell, P. A., Op. cit.
Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1868, vol. vi, p. 393.

on panning a little of the material. This description indicates a type of ore-deposit similar to the lenses that parallel the "House" vein on the property of the Young American mine described in detail on pages 134-139.

These small lenses were worked entirely by open cuts and the ore obtained was washed through sluices or rockers to separate the free gold in the soft material (kaolin), which varied in value from $2 to $20 per ton. After the fine material was washed away the balance consisting of coarse quartz was put through the mill to recover the gold that it contained.

Production.—Mr. Snell believes that about 2,000 to 2,500 tons of ore have been milled, this being derived mostly from the two principal veins but partly from the open cuts on the small lenticular ore-bodies. The property is estimated to have produced from placer gravels and from veins a total of not less than $100,000.[a]

The Collins Mine.

The Collins mine is situated on the east side of the Belzoro property 1 mile northeast of Lantana. It was probably the first mine worked for gold in this district if not in Virginia. Gold was first found in the branch crossing the property, and while the exact date of the discovery is not known, it must have been prior to 1830. The Fishers made preparations to work the gravels, building dams across the branch and installing rockers, but before operations were actually under way they turned the property over to Steven Collins and began work on the Busby branch instead. Mr. Collins washed the branch gravels successfully for several years, and later gold-bearing gravels were found 30 or 40 feet above the branch on the north side. Sluice ways were cut from the bottom of the hill and the gravel worked by hydraulic mining. Little if any vein-mining was ever conducted on the property.

In addition to the mines described above gold has been reported on a number of properties in the vicinity of Lantana, and a little prospecting has been done at several places, chiefly for placer gold. On a property lying south of the Belzoro mine and formerly known as the Marks mine, surface washing was commenced in 1830 by Woodfork and continued for some time by various owners. Other placer mines which have been operated at various times in this neighborhood were known as the Eades, Big Bird, and Laury mines.

The Morgan Mine.

The Morgan mine is located just west of the property belonging to the Young American mine. The placer gravels on this place were early

[a]Snell, P. A., Op. cit.

worked for gold and later some vein mining was done. According to Credner the main vein is 4 feet wide and a smaller parallel vein in the hanging wall was also worked. Before the war, ore was hauled to the Belzoro mill and is said to have yielded 70 pennyweights of gold per day, or about $3,000 in eight months.[a] Later a 10-stamp mill was built but the size of the tailings pile indicates that little ore was milled. At present nothing remains of the mill and the old shafts and pits are completely caved.

The Grannison Mine.

The Grannison mine is situated on the west side of Camp Branch, a mile northwest of Lantana and a mile south of Caledonia. The placer gravels were extensively and successfully worked during the period that preceded the Civil War, and 3 quartz veins were opened up. One of these was worked to some extent by open pits and a shaft 42 feet deep. After the war the veins were reopened and a 10-stamp mill built near the branch, but at present the mill is in ruins and all of the old workings caved. Most of the work seems to have been done a short distance northeast of the mill where there is a series of old shafts and pits extending for about 150 yards in a direction N. 45° E. There are several pits located a quarter of a mile north, said to have been opened on a smaller vein which was very rich.

Atmore, Kent, and Other Properties.

On the Atmore and Kent properties, lying southwest of the Grannison mine, several veins have been explored and a little mining done, but all of the work has been of a superficial nature. Small veins have been prospected on a number of other places in this vicinity, but aside from placer washing practically no mining has been attempted. Nearly all the gravels along Camp Branch and some of the smaller branches that enter it have been washed for gold.

The Bertha and Edith Mine.

Location.—The Bertha and Edith mine is situated on the east side of Big Byrd Creek in Goochland County, 3 miles northeast of Columbia.

History.—The placer gravels along the branches were first worked prior to the Civil War, and the Maple and Camp branches which flow through the property are said to have yielded much gold. In 1877, the Bertha and Edith Gold Mining Company bought the mineral rights and began

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[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, pp. 26-27.

development work on the quartz veins. A little later a Fraser and Chalmers 20-stamp mill was erected to crush the ore and recover the gold. In 1882, the Tagus Mining and Milling Company, which was operating the Gilmer (Young American) mine, 4 miles northeast, obtained a lease and option on the property and began work. During this lease some hydraulic mining was carried on, water being furnished under pressure by a large pump and the gravel washed through sluice boxes. Several veins were prospected by surface openings but most of the underground development was limited to the "Oak Hill" and "Maple Branch" veins. The "Oak Hill" vein was explored by an adit 400 feet long, which drained the hill 75 feet below the summit and was connected with an upper level on which there were 300 feet of drives and cross-cuts.[a] The "Maple Branch" vein was explored by a tunnel, but work had to be stopped on account of bad ground.

In 1897, the Rivanna Gold Mining Company reopened the "Oak Hill" vein and built a cyanide plant to treat the tailings from the stamp mill. Milling had scarcely begun before the whole plant was destroyed by fire in 1898, and since that date no work has been carried on. While the "Oak Hill" vein was being reopened the company prospected the placer gravels in the flat near the mouth of Camp Branch and started to work the deposits, the method being to first remove the overburden with scrapers and then wash the gravel in rockers, but this was discontinued when the mill burned. At the present time the shafts are partly caved and all the underground workings are inaccessible.

Description of veins and country rock.—The country rock in which the veins are located consists chiefly of schists and gneisses of sedimentary origin, and their contact with hornblendic border facies of the granite is only about half a mile southeast of the "Oak Hill" vein. The dominant rock in the sedimentary series is a medium-grained gneiss composed essentially of quartz, sericite, and feldspar in the order named, with a little biotite and a few grains of magnetite. This is the only rock outcropping on the property excepting along the bluffs that border Big Byrd Creek where quartz-sericite schists and hornblende schists occur in places.

The "Oak Hill" vein varies up to 6 feet in width and is said to have averaged about 3 feet. Ore found on the dump consists of ordinary vein quartz containing considerable fine-grained pyrite, which is partly oxidized to limonite, and on crushing and panning it shows fine grains and scales of free gold. Some of the pieces show a little white mica and kaolin un-

[a]Hotchkiss, Jed., Virginia Minerals for the New Orleans Exposition, The Virginias, 1884, vol. v, p. 166.

doubtedly derived from feldspar. A little magnetite is occasionally present. The ore from this vein is said to have averaged a little over $5.00 per ton. The "Maple Branch" vein has a northeast-southwest strike and is said to be much narrower but richer in gold than the "Oak Hill" vein. Miners, who worked on the property when the openings were made, state that this vein carried a large amount of white kaolin. The "House" vein, situated about a quarter of a mile northwest of the other two, has been worked to a limited extent, but nothing definite could be learned concerning it. Float rock picked up on the surface assayed as much as $32.75 per ton. There are some placer gravels remaining on the property that have never been worked (see pages 239-240).

The Pryor Tract.

The Pryor property is located 1½ miles southeast of Tabscott and lies south of the Busby mine. The placer gravels along Busby Branch, which crosses this property, were worked soon after the first discovery of gold in the district. Recently several small shafts have been sunk on the property in the hope of locating the "Waller" vein, but, so far as is known, nothing of value was found.

The Moss Mine.

Location.—The Moss mine is located on the south side of the Columbia-Tabscott road, about 8 miles northeast of Columbia and 1½ miles southwest of Tabscott.

History.—The Moss vein, on which most of the work has been done, is said to have been discovered in 1835 by John Moss.[a] Prof. Silliman,[b] reporting on the property in 1836, found the mine developed by two incline shafts sunk on the vein; one measuring 31 feet along the slant and having a vertical depth of 25 feet, while the other was 50 feet deep, though the lower 20 feet was inaccessible at the time of his visit. The two shafts were connected by an adit 70 feet in length and the vein was exposed throughout the length of these workings. Measurements taken at intervals along the vein ranged from 16 to 30 inches in width and averaged about 24 inches. The inclination, about 45° toward the southeast, and the strike, about north by east and south by west, were conformable with the stratification of the inclosing slaty rocks. A sample was taken by knocking off pieces of ore at intervals of 12 feet along the vein and this, after being

[a]Nitze, H. B. C., and Wilkins, H. A. J., Gold Mining in North Carolina and Adjacent South Appalachian Regions, Bull. 10, N. C. Geol. Survey, 1897, p. 75.

[b]Silliman, B., Remarks on Some of the Gold Mines and on Parts of the Gold Region of Virginia, Amer. Jour. Sci., 1837, vol. xxxii, pp. 98-130.

broken down and subdivided to give a final sample of 9 pounds, was washed and amalgamated; the button of gold recovered in this manner weighed 11 grains, giving the ore a value of about $105 per ton. In another trial Prof. Silliman obtained 6 grains of gold from 3½ pounds of powdered rock in which no gold was visible, and in a third experiment two pounds of ore yielded 5 grains of gold.

Credner states that the Moss mine was worked from 1836 to 1838 by a company (The Richmond Mining Co.) whose shares rose in a year's time from $5 to $300, but fell as quickly to nothing.[a]

The mine was reopened in 1891 and tests made on the ore with a 3-stamp prospecting mill,[b] and during 1904 the property was operated under lease by the Telluric Gold Mining Company.[c] At this time the mine was developed by 2 main shafts, known as No. 1 and No. 2. The No. 1 shaft was sunk on an incline to a depth of 118 feet, and levels run east and west a total distance of 285 feet in ore milling $15 per ton. In the west level a small shoot was encountered which averaged $150 per ton in gold, and 40 ounces in silver. The No. 2 shaft was carried to a depth of 130 feet and levels driven 60 feet east and west along the vein, the ore developed milling $14.40 per ton. A 3-stamp battery was added, giving the mill a total of 6 stamps. Regular assays of tailings indicated an average of $2.00 per ton.

Descriptive geology.—The vein is said to consist of laminated quartz lying in more or less lenticular masses between walls of micaceous slate. Pieces of the ore examined by the writer are in the form of thin plates 0.5 to 1 inch thick, and broken along joint planes spaced 5 to 9 inches apart. Coarse gold, in grains about 0.5 mm. in diameter, is sprinkled along the surfaces of the laminæ, a little pyrite mostly altered to limonite is present, while flakes of white mica and considerable kaolin, probably derived from feldspar, were also noted. Black tourmaline is said to have been common in some of the ore and prisms of this mineral were found in a number of pieces of float on the surface.

Specimens found on the shaft dumps indicate that the wall rock is a dark gray schist with slaty cleavage, composed for the most part of fine-grained quartz and biotite, varying somewhat in their relative proportions but with the quartz always largely in excess. A few small black needle-like prisms

[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, p. 27.

[b]Eng. and Mng. Jour., 1901, vol. lii, p. 108.

[c]Froehling and Robertson, A Hand-Book on the Minerals and Mineral Resources of Virginia, 1904, pp. 51-52.

of tourmaline or hornblende are also present. The soft running ground which is reported to have given much trouble in shaft sinking, was probably due to disintegrated schist of this character saturated with water.

Pieces of hornblende schist were also found on one of the dumps. This is a greenish-gray, medium-grained rock composed of dark green hornblende in crystals ranging up to 2 or 3 mm. in diameter, fine-grained, white quartz and feldspar, and numerous pink garnets, usually less than 1 mm. in diameter. In thin section under the microscope the hornblende is light green in color, very ragged in outline, and micropoikilitic from numerous inclusions of quartz and feldspar. Quartz, the second mineral in relative abundance, frequently contains inclusions of broken zircons, and gas- and liquid-filled cavities. The feldspar is plagioclase, probably andesine, and in places shows albite twinning though this is usually absent. The large, light pink garnets which are plentiful in the slide are often ragged in outline and contain many included quartz grains. Chlorite, partly derived from garnet but mostly from the hornblende, is present in light green flakes. A very little biotite, scattered grains of magnetite, and some pyrite, partly altered to limonite, make up the minor accessories. In the absence of a chemical analysis or data bearing on the structural relations of this rock it is impossible to state whether it is igneous or sedimentary in origin, but the writer is inclined to the latter alternative.

An old shaft, partly caved, which is located close to the county road is said to have been sunk to cut the Hodges vein. Partly decomposed garnetiferous mica schist is exposed on the dump.

The Busby Mine.

The Busby mine lies 8½ miles northeast of Columbia and 1 mile southwest of Tabscott, joining with both the Moss and Bowles properties. It was one of the first gold mines in the State to be worked, the placer gravels on Busby Branch having been washed by the Fishers as early as 1829 or 1830. In working up the branch, the Busby vein was discovered, and then a small wooden stamp mill run by horse-power was put up by the Fishers and D. W. K. Bowles.

In 1836, when Prof. Silliman[a] visited the district to report on the Moss and Busby mines, they were being developed by the Richmond Mining Company. A shaft had been sunk to a depth of 57 feet with the

[a]Silliman, B., Remarks on Some of the Gold Mines, and on Parts of the Gold Region of Virginia, founded on personal observations made in the months of August and September, 1836, Amer. Jour. Sci., 1837, vol. xxxii, pp. 98-130.

expectation of striking the vein at 70 feet, the vein having first been proved by 4 prospecting pits 20 to 26 feet in depth. These openings showed the vein to be from 12 to 30 inches wide, averaging 15 to 18 inches. The vein quartz, as described by Prof. Silliman, has a coarsely granular texture with a strong resemblance to coarse lump sugar, much of it being white and apparently free from all foreign matter other than the inherent gold. A 6-pound sample picked at random from a large pile was crushed, washed, and the gold amalgamated with mercury; upon retorting it yielded 6 grains of gold worth $4\frac{1}{12}$ cents per grain. This is equivalent to over $81 per ton. A picked sample containing small points of visible metallic gold, when treated in the same way, yielded 6 grains of gold from 2 pounds of ore, or about $250 per ton.

Notwithstanding the reported value of the ore, comparatively little mining seems to have been carried out on the property, and when it was visited by Credner in 1865 the mill was in ruins.[a] He states that the continuation of the Moss vein was exposed by 4 shafts the first and last of which were one mile apart.

When visited by the writer in 1910 the shafts had caved so that few observations could be made. Several old pits are located about 50 yards north of the Columbia-Tabscott road and in line of strike with the Tellurium vein system. On the dump of one of these openings pieces of quartzite were found identical in appearance with the material from the "Big Sandstone" vein, but whether it has been mineralized at this point or not, could not be determined. About 100 yards south of the road a small pit had been sunk, apparently on a ferruginous quartzite similar to that known as the "Hodges" vein at the Scotia mine.

The Payne Tract.

The Payne tract is located on the south side of the county road half a mile southeast of Tabscott. It adjoins the Busby mine and was formerly a part of that property. There are a number of old surface cuts and caved shafts which extend in a line running about N. 58° E. A large pile of mill tailings a short distance below the openings indicates the site of the old mill of which no other trace remains. The mill that Credner found in ruins when he visited the Busby mine was probably located at this point. In 1911 an attempt was being made to reopen one of the old shafts.

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[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. of Mng., 1869, vol. vii, p. 27.

The Waller Mine.

Location.—The Waller mine is situated in Goochland County half a mile southeast of Tabscott and about 10 miles northeast of Columbia, the nearest railroad station.

History.—The Waller mine was discovered in 1831, and during that year Cole and Woolfork carried on surface washings for several months. Veins were discovered by Moss in 1832, and a vein 6 feet thick is said to have been opened by the Fishers and worked until the land was purchased by Wm. K. Smith. Later it was sold to Richards, of New York, who worked the mine 12 months and then sold it to an English company for a large sum. After two years, during which it is said to have been badly managed, the property was divided and sold in two parts. Since that time only the western part of the old estate has been known as the Waller mine. In 1865, Turner, Hughes & Co. sank a shaft and did some development work, but since that date nothing has been done, aside from 30 days' work in 1876, until the present company began operations in 1910.[a] During the latter year a shaft was sunk to a depth of 72 feet and two cross-cuts driven northwest at depths of 45 and 60 feet, respectively. A small vein, said to be the Waller vein, was encountered in the 60-foot cross-cut, but the drive which was started southeast along the vein soon ran into old workings. Another shaft was started in 1911 to strike the vein at greater depth, but when the property was visited in the summer of that year the vein had not been reached. A small mill is said to have been operated on the property in the early days but no trace of it remains to-day. Before the property was divided, veins belonging to the Tellurium system which crossed the northwestern portion of the property were also developed to some extent.

Descriptive geology.—The mine is situated in an area of schists and quartzites not far from their contact with the hornblendic border facies of the granite, which is found outcropping a short distance southwest of the property. Because of lack of exposures it is not possible to accurately locate the contact at this point, but many pieces of hornblende schist were found on the surface within less than 200 yards southwest of the vein. About a quarter of a mile northeast of the vein a small pit was sunk in prospecting for iron. The material encountered seems to have been a ferruginous quartzite similar to that found elsewhere in the district. About half a mile northwest of the mine occurs the same series of quartzites and schists found at the Tellurium mine.

[a]Most of the facts stated above were taken from "The Natural Wealth of Virginia," by J. R. Hamilton, *Harper's Magazine*, 1865, vol. xxxii, pp. 32-42.

The strike of the Waller vein at the surface, as indicated by the old open cuts and caved stopes which extend for about 300 yards along the outcrop, is N. 58° E. When the mine was examined by the writer, the vein was exposed for a distance of only 25 feet along the strike at a depth of 60 feet below the surface. At this point the dip was about 40° toward the southeast and the strike N. 60° E. The width of the vein where it could be measured ranged from 4 inches down to less than an inch, and was composed for the most part of quartz, feldspar, more or less kaolinized, and a little limonite resulting from the alteration of pyrite. The relative proportions of these constituents varied greatly; where widest the vein consisted almost entirely of white vitreous quartz, but in most places feldspar was abundant, and in some of the narrower portions was dominant. The limonite was commonly mixed with kaolin and quartz to give an earthy, yellowish-brown material, which often contained much coarse gold.

The textural relations of the quartz and feldspar are similar to those of a typical pegmatite and in places there is a suggestion of graphic intergrowths. The feldspar individuals range up to 1 cm. or more in diameter, and in the wider portions of the vein are more or less concentrated near the walls. The gold when visible occurs in irregular grains and rough wire-like masses, some of which measures 3 mm. in length, and is usually associated with decomposed earthy material heavily stained with limonite. Specks of gold may occasionally be seen in feldspar and clear, unstained quartz, and more rarely in the wall rock close to the vein.

Microscopic examination of the vein rock in thin section (Spec. 217) shows no accessory minerals other than a little sericite derived from the feldspars. The quartz is nearly free from optical distortion and contains numerous gas- and liquid-filled cavities. These cavities occur partly in irregular branching and interlaced forms, and partly in smaller spherical and elliptical shapes which are usually grouped in rows and planes. In places the inclusions are so small and plentiful as to give the quartz a clouded appearance even under a magnification of 200 diameters. The feldspars are extensively kaolinized and show some alteration to sericite, but apparently consist entirely of acid plagioclase (albite-oligoclase to oligoclase).[a] Twinning after the albite law is common, though much of

[a]Dr. E. S. Larsen, Jr., using the immersion method, determined these feldspars to be albite-oligoclase to oligoclase and states that the fresher crystals appear to be oligoclase. The indices of refraction as determined by him are:

$$\alpha = 1.535 \pm 0.003 \text{ to } 1.538 \pm 0.003$$
$$\gamma = 1.543 \pm 0.003 \text{ to } 1.547 \pm 0.003$$

the feldspar is unstriated. A photomicrograph of some of the striated feldspar is shown in Pl. VIII, fig. 2. The narrow veinlet crossing the feldspar is composed of quartz.

The wall rock is fine-grained and badly decomposed, so that it is very difficult to obtain specimens fresh enough for identification. The rock exposed on the hanging wall side of the vein is dark blue in color and consists essentially of quartz and magnetite in grains that are too small for sight determination. For a distance of 3 feet or more from the vein there are numerous veinlets composed of quartz and feldspar, which range from an inch or more in thickness down to threads and lenses microscopic in size, and which are approximately parallel to the main vein. Limonite and iron-stained cavities due to the oxidation of pyrite occur in places, and there is probably some gold, for these veinlets appear to be essentially the same as the vein in which gold was identified. Small flakes of biotite usually occur along the contact between the veinlets and the country rock, and the mica is plentiful along both walls of the principal vein. The rock on the foot-wall side was not as well exposed. Where it could be examined it was much weathered, but appeared to consist of biotite, kaolinized feldspar, and quartz. Pieces of rock from the hanging wall sometimes contain small, light brown crystals, often radiating, which resemble sillimanite, but are too small and too much decomposed for positive identification.

A thin section (Spec. 219) of the hanging wall rock was also examined under the microscope. It is schistose in structure and consists of a fine-grained ground-mass of quartz, magnetite, and a little feldspar, in which there are numerous small irregular lenses and veinlets composed of coarser grained quartz and feldspar. The quartz grains in the ground-mass show wavy extinction, the magnetite is present in idiomorphic grains, and the feldspar, which seems to be chiefly acid plagioclase, is more or less kaolinized. The quartz in the lenses shows no optical distortion, and frequently contains numerous small fluid-filled cavities. Many of these cavities contain rapidly vibrating bubbles. A little zircon and titanite are also present as inclusions in the quartz. Feldspar is not very plentiful, and is chiefly concentrated along the border portions and at points where the lenses pinch out. Most of the feldspar crystals show Carlsbad twinning and are probably orthoclase, but a little acid plagioclase is also present.

On the surface near one of the old openings pieces of vein rock were found which consist of intercrystallized quartz and calcite. The calcite is coarsely crystalline, has curved cleavage surfaces, and contains much iron and a little magnesium. Dark green hornblende partly altered to chlorite and a little pyrrhotite are also present in the calcite and along its margins. Other pieces of rock on the old dump have a banded structure and are composed of alternating layers in which the dominant minerals are, respectively, coarsely crystalline, dark green hornblende and white finer-grained calcite. Lenses of quartz occur in places and there is a little pyrrhotite and some pyrite present.

The Fleming Mine.

Location.—The Fleming mine is situated in Goochland County about a mile northeast of Tabscott and on the southeast side of the county road.

History and description.—The placer gravels on this property are said to have been washed during the early days of gold mining in the district. Underground work was started by General Cook in 1846 and a 6-stamp mill operated by him is said to have yielded on occasions as much as $200 per day. This success, however, was short-lived as the vein was soon lost. At this time two shafts were sunk to depths of 60 and 35 feet, respectively. During its early history the property was known as Hodge's mine, but in 1848 it was sold to the L'Aigle d'Or Company of New York.[a] Little development work was attempted until after the Civil War, when the mine was reopened by several small shafts, and since that time it has been known as the Fleming mine.

When the property was visited in 1910 all of the openings were inaccessible; a series of old pits and shafts was seen extending in a direction N. 60° E. for about 150 yards, and in one of the shafts decomposed schists were exposed having a strike of N. 61° E. and a dip of 45° toward the southeast. A few pieces of vein quartz were found on the dump, but they showed little evidence of mineralization.

Shannon Hill.

Shannon Hill is the most northeasterly point within the area where gold has been found. Some prospecting was carried on here years ago,

[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, p. 26.

but nothing further seems to have been done. Credner examined the property in 1865 and states that a lode, 1 to 3 feet wide and paralleled by two smaller veins, was exposed by surface pits. The strike is given as N. N. E. and the dip 40° to the east. The veins are said to consist of white translucent tabular quartz with a great deal of earthy oxide of iron and some gold. Garnetiferous mica schist outcrops in the road at Shannon Hill, having a strike of N. 45° E. and a dip of about 45° southeast. While considerably decomposed it is apparently similar to the wall rock at the Tellurium mine and probably represents the same formation. Placer gravels were washed on this property before the Civil War and considerable gold is said to have been recovered.

The Benton Mine.

Location.—The Benton mine is located in Goochland County about three-quarters of a mile northeast of Tabscott and on the northwest side of the county road.

Description.—This property was explored by a shaft, now inaccessible, and the size of the dump indicates that it reached a considerable depth. The country rock found on the dump is a garnetiferous schist similar to the wall rock at the Tellurium mine, and pieces of vein quartz were seen that contained a little kaolinized feldspar and some white mica. The property is in direct line of strike with the Tellurium system of veins, and this fact together with the material found on the dump indicates that the vein is similar in its general characteristics to those described under that mine. There is a number of old pits and caved shafts between this point and Tabscott, which were probably sunk in prospecting the same vein or others belonging to this system, but the openings are so old that the material on the dumps has completely disintegrated, and therefore no definite information could be obtained concerning the exposures. A few pieces of massive diorite, evidently derived from some dike, were found on the surface. The rock is described in detail on page 85.

The Tellurium Mine.

Location.—The Tellurium mine, located 7½ miles northeast of Columbia and 2½ miles southwest of Tabscott, lies partly in Fluvanna and partly in Goochland counties.

History and description.—It was one of the first properties in Virginia on which vein mining for gold was attempted, and its history differs from that of most mines in this section in that the veins were discovered and worked before the placer gravels. The first discovery on the place was made in 1832 by G. W. Fisher while hunting, and in 1834 the property was leased from its owner, Mr. Hughes, by Geo. Fisher, his two sons, G. W. and J. A. Fisher, and Judge D. W. K. Bowles.

At first the ore was raised and crushed by hand, and the gold separated from its gangue by washing in a box. The crushing was carried on in wooden mortars lined with iron, the heavy pestles being attached to sweeps which were likewise operated by hand. Later an arrastra driven by horse-power was installed, and finally a small stamp mill was built on the branch about one mile below the mine. This was probably the first stamp mill, or "pounding mill" as they were originally called, to be erected in this country, and it is supposed that the innovation was derived from Europe. According to Nitze and Wilkins,[a] a 6-stamp mill was in operation at the Tellurium mine as early as 1836. The ore was crushed on an iron die plate by 50-pound wooden stamps with iron shoes; the stamp stems were square and did not revolve as in later mills, for the cams worked in slots cut into the stems.

The mine was in continuous and profitable operation for 14 years under the Fisher-Bowles lease, and during that period the work was confined to the "Little" and "Middle" veins which are said to have been the richest, but very little authentic information regarding the production or the value and character of the ore is obtainable at this date. The "Little" vein is said to have averaged less than a foot in width and the deepest workings were only 65 feet, though as a rule the vein pinched out before this depth was reached. According to G. W. Fisher 100 pounds by weight of the richest ore ever obtained from this vein, on crushing and washing, yielded 210 pennyweight of gold.[b] The "Middle" vein is said to have averaged 1½ to 2 feet in width but the ore was not so rich as the "Little" vein.

Dr. Gray, in a letter to Dr. Thomas Pollard, gives the average value of the ore obtained from the two veins during this 14-year period as $100 per ton.[c] Prof. B. Silliman visited "Fisher's or Hughes' mine," as the property

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[a]Nitze, H. B. C., and Wilkins, H. A. J., Gold Mining in North Carolina and Adjacent South Appalachian Regions, Bull. 10, N. C. Geol. Survey, 1897, p. 35.

[b]Statement made to the writer by R. H. Fisher, nephew of G. W. Fisher.

[c]Hotchkiss, Jed., The Tellurium Mine and Virginia Gold Mining, The Virginias, 1881, vol. ii, p. 85.

Pollard, Thomas, The Gold Belt of Virginia in "Gold, Its Occurrence and Extraction," by A. G. Locke, New York, 1882, pp. 182-190.

was variously called at that time, in 1837, and quotes Mr. Fisher as saying, that the average value of the ore was $3.15 for every 100 pounds, while the cost did not exceed 30 to 35 cents per hundred pounds.[a] According to local report, the lessees paid a royalty of 10 per cent. of the gold recovered, and during the period of the lease Mr. Hughes received as his share $13,000 or $15,000, the accounts differing as to the exact amount, making a total production of $130,000 or $150,000.

In 1848, the property was bought by Commodore R. F. Stockton, who erected a 40-stamp mill and proceeded to work the mine on a larger scale. His operations extended over a period of about 9 years, and then the mill was burned to the ground. The "Middle" and "Little" veins were worked to a limited extent, but most of the mining was confined to the so-called "Big Sandstone" vein, which averaged about 3 feet in width and in places reached 6 feet or more. The deepest shaft was sunk in the hanging wall about 300 feet from the outcrop and is reported to have reached a depth of 136 feet, but the other openings would not average 45 feet, and practically all of the ore came from above the water level. Starting from a small branch that crosses the outcrop, a tunnel was driven along the vein, and nearly all the stoping was above this level. These old workings are now mostly caved, but they can be traced across the property on the surface for a distance of about 1,500 feet along the strike.

Many remarkable tales cluster about the name of Commodore Stockton and the fortunes said to have been made by him in Virginia gold mines, but few of these can be verified. Estimates of the gold extracted by him from the Tellurium veins vary from $75,000 to over $1,000,000, but the lower figure is probably more nearly correct.

After the mill had burned the property was sold and no further work was carried on until after the war. Since that time there have been spasmodic attempts to reopen the mine, but none seem to have been attended with any great degree of success. About the year 1880, a 10-stamp mill with amalgamated copper plates was built, and for a short time the mine was operated under lease. Most of the ore mined at this time was taken from the "Big Sandstone" vein. A few years later the stamp mill was pulled down and replaced by some kind of a revolving mill, which was used to treat ores from the "Gold Hill" veins on the Bowles tract, adjoining the Tellurium on the northeast. About the year 1890, two Tremain steam stamps were installed on the property, but they were never used to any extent.

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[a]Silliman, B., Remarks on Some of the Gold Mines, and on Parts of the Gold Region of Virginia, Amer. Jour. Sci., vol. xxxii, pp. 98-130.

The last work done on the property was in 1909-1910, when the Argus Gold Mining Corporation cleaned out part of the old workings on the "Big Sandstone" and "Middle" veins, and sank a 3-compartment incline shaft on the "Big Sandstone" to a depth of about 90 feet measured along the dip. Drives were started in either direction along the strike of the vein, but had only progressed a few feet when the mine was closed down. One of the old Tremain stamps was set up again and used in testing a few tons of ore from the "Middle" and "Big Sandstone" veins.

Present underground development.—When the property was examined by the writer in the summer of 1910, the "Big Sandstone" vein was exposed by the new 90-foot incline with short drives at the bottom, and by an old drain tunnel which had been reopened for a distance of 90 yards along the vein, and which connected with a shallow incline. The "Middle" vein was exposed by an incline shaft 50 feet deep and about 125 feet of drives along the vein, all above water level. A little stoping had been done on the latter vein. While there has been a number of other shafts and openings made at various times, they are not now accessible.

The Tellurium Vein System.

Introduction.—The geological descriptions given below will suffice for all properties located along the line of the Tellurium vein system, and under each mine only such details will be referred to as are not mentioned in the description of the system as a whole. The Tellurium system of veins has been developed almost continuously for a distance of a mile, and prospected at short intervals for 5 miles or more along its line of strike. The greatest amount of development work, however, has been done at the Tellurium and Bowles mines. The only openings accessible, when the area was studied by the writer, were located on the adjoining properties of the Tellurium and Scotia mines; and therefore the detailed geological descriptions will be limited to these two properties; but everything that could be learned concerning development work done elsewhere along the belt, indicates that the general structural relations are everywhere the same, though the veins have proved profitable in only a limited number of localities.

General description of veins and country rock.—The veins belonging to the Tellurium system are situated in a series of fine-grained quartz-mica schists, usually garnetiferous, interbedded with fine-grained, even-granular quartzites, some of which contain much hematite and magnetite. All the gold-bearing veins observed occur either in quartzite beds, which

are very narrow, or in the schists close to them. This series of sedimentaries is bounded on the northeast by a fine-grained granite, which in places, especially near its borders, contains areas of hornblende schist. Exposures are very rare except where openings have been made in prospecting for veins, so it is not possible to trace the exact boundaries of the granite area, but its field relations, the lack of schistosity in most places, and the extensive metamorphism exhibited by the schists in the vicinity, indicate that it is later in origin than the sedimentaries. The granite is exposed within less than half a mile of the Tellurium veins and probably comes much closer. Specimens found on one of the old dumps at the Tellurium indicate that there are probably apophyses from the granite, if not the main mass itself, within a few yards of the veins, and this hypothesis is supported by the extreme metamorphism of the rocks at the few places where they are exposed on the northeast side of the veins.

The veins which have received the greatest amount of attention on the Tellurium property are known as the "Big Sandstone," and "Middle," and the "Little" veins. In addition to these the "Hodges" vein on the Scotia property and several other veins belonging to the system have been prospected to a limited extent.

The so-called "Big Sandstone" vein consists of a bed of quartzite 2 to 6 feet thick, cut in places by irregular gold-bearing veinlets, composed essentially of quartz with more or less feldspar and a little pyrite. (See fig. 12.) The veinlets range up to about 1 foot in width, and in their vicinity the quartzite is often impregnated with a very small amount of pyrite, chiefly along bedding planes, and carries a little gold. This bed of quartzite is remarkably uniform wherever it has been observed, and apparently extends continuously for a distance of 3 miles and possibly farther, but it is probably gold-bearing only in places and where it has been mineralized by the vein-forming solutions. It has an average strike of N. 64° E. and dips at an angle of about 45° toward the southeast.

The outcrop of the "Middle" vein is parallel to the "Big Sandstone" and located about 30 feet southeast, dipping in the same direction at an angle of 43°. Where exposed it consists of a series of lenses varying from 3 feet down to a knife edge in thickness, and is composed of quartz with variable amounts of feldspar, pyrite, largely oxidized to limonite, and a little gold. The lenses are enclosed by a thinly foliated, garnetiferous schist the folia of which conform to the flexures of the vein. (See fig. 13.)

The "Little" vein, which is not at present exposed, is said to parallel the "Middle" vein at a distance of 20 feet to the southeast. Descriptions

indicate that it is similar in character to the "Middle" vein but narrower, averaging less than a foot in width, and richer in gold. The deepest workings on the "Little" vein are said to have attained about 65 feet from the surface, but it usually pinched out before that depth was reached.

A vein known as the "West" vein is exposed by a shaft 40 yards northwest of the "Big Sandstone" vein at the Tellurium. Where exposed it has a strike of N. 27° E., a dip of 80° to the east, and is about a foot wide. Quartz found on the dump yielded colors of free gold on panning. The nonconformity of this vein in strike and dip with the other veins of the Tellurium system, suggests that it may belong to the Gold Hill system described on pages 176-179, but the shaft was partly caved and the vein and wall rock could not be examined closely.

The so-called "Hodges" vein, developed to some extent on the Scotia property, is a lenticular bed of ferruginous quartzite, which narrows from a width of over 6 feet to a fraction of an inch within a distance of only 40 feet. The quartzite is cut by a few small stringers of gold-bearing quartz, which have mineralized the enclosing rock to a limited degree. While this quartzite pinches out and is not continuous in its course, as is true of the "Big Sandstone" bed, pieces of float similar in every way are plentiful at several points in approximate alignment with one another in a northeast-southwest direction.

At a number of localities on the Scotia, Tellurium, and other properties along the course of the Tellurium vein system, there are bold outcrops of large veins, consisting of massive white quartz carrying a small amount of kaolinized feldspar. Some of these veins are 10 to 20 feet wide and can be traced for several hundred feet along the strike. They are reported to carry traces of gold but none of them have been worked.

The wonderful uniformity and persistence of the bed of quartzite, known as the "Big Sandstone" vein, and hitherto regarded as a true vein, has given rise to a mistaken idea concerning the continuity of the veins in this district. The "Little" vein and the "Middle" vein and even the gold-bearing stringers in the "Big Sandstone" vein itself, are not continuous for great distances, though it is probable that sections across the vein system, at two or more points, would intersect approximately the same number of veins; for while the veins frequently pinch out, they may be replaced by others a little to one side or farther along the line of strike.

Detailed descriptions of veins and wall rock.—The sketch given in fig. 12 shows the appearance and structural relations of the "Big Sandstone" vein in the northeast drive from the bottom of the new incline shaft at

the Tellurium mine, which is about 65 feet from the surface; and this occurrence is typical of the vein wherever it could be observed. Here the quartzite bed is 6 feet thick, and distinctly laminated parallel to the bedding, the laminæ being disturbed in places where the quartz veinlets cut across them. At the top of the bed the quartzite grades into a fine-grained quartz-sericite schist, and finally into the garnetiferous schist which forms the foot-wall of the "Middle" vein; but at the bottom the contact with the underlying rock is sharp and well defined. Below the quartzite there is a bed 4 to 5 inches thick, consisting for the most part of biotite, often altered to chlorite, large garnets, and a little feldspar. The rock underlying this bed is exposed for a short distance only. It is highly laminated and finer grained, but in mineral composition resembles the rock above except for the presence of more quartz. Detailed petrographic descriptions of all of these rocks are given below.

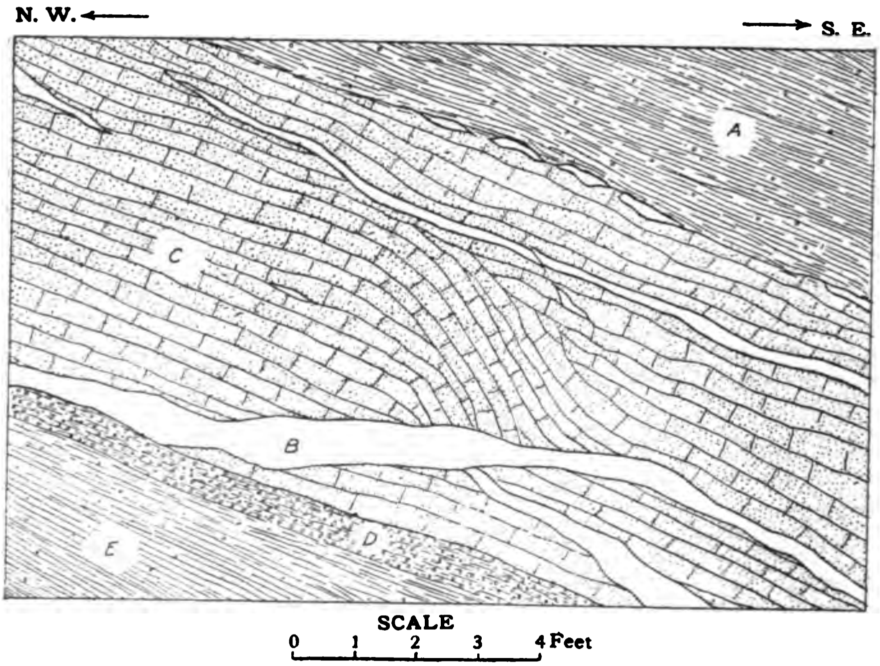

Fig. 12.—Sketch of quartzite bed cut by gold-bearing veins, Tellurium mine. *A*, hanging wall schist; *B*, quartz-feldspar veins; *C*, quartzite; *D*, garnetiferous foot-wall layer; *E*, foot-wall schist.

The individual veinlets in the quartzite range up to 14 inches or more in width, and commonly follow bedding planes though they frequently cut directly across. Where the bedding planes are cut by veinlets, little spurs from the quartz sometimes extend out along them for a short distance. Lenses of vein quartz occasionally take the place of veinlets at the top of the quartzite, but rarely occur within the bed itself, and where seen were always small. The veinlets are composed essentially of white to translucent, coarsely crystalline quartz, and kaolinized feldspar is usually present, in places becoming an important gangue mineral. Pyrite is commonly a constituent in small quantity but rarely exceeds one per cent.; native gold occurs in small grains and scales that may usually be detected on panning the crushed ore; and sphalerite, tetradymite, and tellurium (?) have been identified as rare accessory minerals. In the oxidized zone near the surface, joint planes and fractures in the quartz are frequently stained with black oxide of manganese.

The feldspar is distributed throughout the quartz veins in small angular shapes, but is more plentiful near the border portions where it sometimes forms small lenticular bands or streaks parallel to the walls, and may constitute as much as 10 per cent. of the mass. Rarely it occurs in lenticular masses 3 inches or more in maximum diameter. In most places where the vein is exposed the feldspars are completely altered to kaolin, and it is difficult to obtain specimens sufficiently fresh to admit of their determination.

The freshest feldspars were obtained from a piece of vein quartz found on a shaft dump at the Scotia mine, and which evidently came from the foot-wall side of the quartzite bed, for some of the underlying rock was firmly attached. In the hand specimen (143-A) the feldspars occur in somewhat angular individuals ranging up to 0.75 cm. in diameter, and are white to light yellow in color and show good cleavage. While sparingly scattered throughout the quartz they are more plentiful near the contact with the country rock, forming perhaps 10 per cent. of the mass. A little chlorite, occurring chiefly near the contact, white mica and an infinitesimal amount of pyrite make up the chief minor constituents. A few thin plates of ilmenite occur in the quartz near the wall rock. Under the microscope the feldspars show extreme alteration to kaolin and sericite, but multiple twinning can be detected on some of them, and this with the index of refraction identifies them as oligoclase-andesine.[a] There is probably some

[a]The indices of refraction as determined by Dr. E. S. Larsen, Jr., using the immersion method, were $\alpha = 1.542 \pm 0.003$ and $\gamma = 1.551 \pm 0.003$.

orthoclase present but it could not be positively identified. The quartz in the slide shows some optical distortion and contains numerous gas- and liquid-filled cavities.

Pyrite nowhere seems to be an abundant constituent of the veins cutting the quartzite. It is usually present in small quantities, rarely amounting to more than 1 per cent., and wherever observed was fine-grained.

Gold occurs chiefly in the native state and can frequently be detected by panning. In a piece of the vein quartz obtained within 6 feet of the surface, close to the incline shaft at the Tellurium mine, gold is present in small flakes about 0.25 mm. in diameter. At greater depth much of the gold is probably contained in pyrite.

A small amount of black sphalerite was identified in vein quartz from one of the stringers in the quartzite, but this mineral seems to be very rare in the veins of the tellurium system.

Tetradymite has been identified in ore at the Tellurium mine, being first analyzed by Coleman Fisher, Jr.,[a] and later by Dr. F. A. Genth.[b] The analysis given by the latter is as follows:

Analysis of tetradymite from the Tellurium mine, Virginia.

(Dr. F. A. Genth, analyst.)

	Per cent.
Bismuth	51.56
Tellurium	49.79
Selenium	trace
Sulphur	none

Genth states that in the specimen examined by him tetradymite occurs "in broad folia, sometimes 1 inch in diameter, implanted in a decomposed micaceous slate. . . . Before the blowpipe it fuses readily giving out a faint but distinct odor of selenium, leaving on charcoal white incrustations with a yellow center." Elsewhere he states that the tetradymite from the Tellurium mine is frequently interlaminated with gold, and experiments made by him proved that gold was easily precipitated from dilute solutions by tetradymite.[c] His description of the gangue indicates that the specimen was probably obtained from the wall of the "Middle" or "Little" vein, rather than the veinlets in the quartzite bed, but these veins are all identical in their mineral composition and mode of formation.

[a] Amer. Jour. Sci., vol. vii, 2d ser., p. 282.

[b] Genth, F. A., Contributions to Mineralogy, Amer. Jour. Sci., 1855, vol. xix, 2d ser., pp. 15-16.

[c] Genth, F. A., Contributions to Mineralogy, Amer. Jour. Sci., 1859, vol. xxviii, 2d ser., pp. 254-255.

Tellurium is mentioned by Credner as being present in the form of a coating together with gold, but the mineral seen by him was probably tetradymite.[a]

In order to show the distribution of the gold and the relative degree of mineralization, average samples of the veinlets and of the quartzite were carefully taken in the face of the drive sketched in fig. 12. The elements, gold, silver, iron, and sulphur, were determined in each of these samples and are tabulated below. The percentage of pyrite given in the table was computed from the amount of sulphur found, based on the assumption that all of the sulphur present is in the form of pyrite, which is essentially correct. The excess iron is present chiefly in the form of limonite, with a little chlorite, and possibly some ilmenite.

Partial analyses of ore from the Tellurium mine, Virginia.

(E. E. Burlingame & Co., analysts.)

	Vein quartz.	Quartzite.
Gold (ounces)	0.12	0.02
Silver (ounces)	trace	....
Iron (per cent.)	1.00	3.60
Sulphur (per cent.)	0.16	0.41
Pyrite (per cent.)	0.30	0.77

The quartzite which forms the greater portion of the "Big Sandstone" vein is fine-grained, even-granular, and light gray to almost white when fresh, turning to light brownish-gray or pink on weathering. The rock has distinct schistosity parallel to the bedding, and when examined on fractures that cut across the schistosity it appears to consist entirely of quartz, while on surfaces paralleling the schistosity fine scales of sericite can always be distinguished and are usually abundant, giving the quartzite a high luster. A little fine-grained pyrite may be recognized in places, but is never an important constituent. In a single instance, crystals of muscovite over 2 cm. in diameter were found in quartzite adjacent to one of the veinlets.

In thin sections (Specs. 135, 147, and 189) under the microscope, the quartzite is composed essentially of interlocking quartz grains, less than 1 mm. in maximum diameter and averaging about 0.25 mm., which are partially oriented with their greater diameters roughly parallel to the schistosity. The quartz grains are so extensively recrystallized that they

[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, p. 9.

furnish little evidence of their former size and shape. They usually show some optical distortion but little if any granulation, and contain occasional small fluid inclusions. Sericite is always present in small scattered flakes mostly parallel to the schistosity. The feldspars (orthoclase and acid plagioclase) are common in specimens of quartzite obtained near the veinlets, and seem to be rare or absent elsewhere in the quartzite. Where abundant the feldspars occur filling interstitial spaces between quartz grains, and in long, irregular, more or less broken lines parallel to the schistosity, indicating that they were formed later than the quartz, and suggesting that the feldspars may have been introduced into the rock by the vein-forming solutions. The feldspars are partly kaolinized and show some alteration to sericite. The alteration of the feldspars together with their low index of refraction render easy their differentiation from quartz even where twinning is absent. The minerals chlorite, zircon, titanite, rutile, and ilmenite, partly altered to leucoxene, are present in small but varying quantities as unimportant accessory constituents.

The contacts between the stringers of vein quartz and the quartzite are well marked and easily recognized in the hand specimen because of difference in color and granularity, but under the microscope (Spec. 190) the contact is less sharply defined and is more of a gradation. The quartzite is completely recrystallized, so that the individual quartz grains interlock with those of the vein quartz, and the only difference between them is one of relative size. In the former the grains are seldom over 1 mm. in diameter, while in the latter the quartz individuals average from 2 to 3 mm. The quartz grains in both vein and quartzite show irregular, interpenetrating boundaries, strain shadows, and slight peripheral granulation. The vein quartz is practically free from impurities other than minute gaseous and liquid inclusions. The quartzite contains much feldspar, chiefly orthoclase with some acid plagioclase, which shows slight kaolinization and partial alteration to sericite. Sericite in small flakes is distributed throughout the quartzite, pyrite is present, usually in small cubes, and the minerals chlorite and zircon occur as minor constituents.

A specimen (188) found on an old dump at the Tellurium mine, contains a layer of rock 3.5 to 4 inches thick, which consists of fine-grained, impure quartzite, or schist interleaved with numerous narrow veinlets and lenticular eyes of quartz 1 mm. to 1 cm. in width. This layer was interbedded with the normal quartzite. Microscopic examination shows that the veinlets and lenses are composed chiefly of coarsely crystalline quartz,

with minor amounts of feldspar—albite or albite-oligoclase and perhaps some orthoclase. The quartzite is very fine-grained and consists of quartz, feldspar, sericite, biotite, chlorite, pyrite, and a little titanite. The feldspars in the veinlets frequently have good crystal outline and range up to 1 mm. or more in diameter. They usually occur near the border portions of the veinlets projecting into the fine-grained quartzite, and in places appear to be completely separated from the veinlets. These feldspars, while well formed, show rough outlines under the microscope, because along their boundaries the feldspars fill up the inequalities caused by irregularities in the adjoining quartz grains. Some of the feldspars show albite twinning but many are unstriated.

By decrease of quartz and increase of mica the quartzite passes into the overlying schists. In the hand specimen (141) the rock from the hanging wall of the "Big Sandstone" vein, where it was cut by a vertical shaft at the Scotia mine, is a light brown, fine-grained, schistose quartzite; and in thin section under the microscope it is even-granular, being composed of roughly rounded quartz grains, showing little or no optical distortion, and decreasing amounts of biotite, sericite, and chlorite. There is probably a little feldspar present, but it could not be positively identified. Some of the biotite shows partial alteration to chlorite. The minor accessory minerals are a little pyrite, chiefly along bedding planes, small grains of ilmenite, largely altered to leucoxene, and occasional inclusions of zircon and rutile.

Another specimen (142) from the same locality is a fine-grained, light gray schist composed chiefly of quartz and sericite with scattered flakes of biotite and chlorite, and occasional garnets 1 to 3 mm. in diameter. Other minerals present are pyrite, zircon, titanite, and leucoxene.

Between the quartzite and the middle vein the rock is mostly a fine-grained, light bluish-gray schist composed essentially of quartz, sericite, and biotite. In places it contains impure garnets 1 to 2 mm. in diameter, and sometimes there is much fine-grained pyrite present.

The thin strip of rock underlying the quartzite (see fig. 12) in many ways resembles the garnetiferous bed that occurs on the east side of the quartzite near New Canton (see pp. 107-108), and elsewhere, except that no sillimanite or cyanite could be identified in the rock at the Tellurium mine. In color the rock varies from dark gray where freshest to dark brown or greenish-brown. It consists chiefly of numerous reddish-brown garnets ranging up to 5 mm. in diameter, imbedded in a schistose ground-mass of biotite usually altered to chlorite. In thin sections (Specs. 186-A and -B)

under the microscope much feldspar—both acid plagioclase and orthoclase —can be distinguished, and the minerals, quartz, ilmenite, mostly altered to leucoxene, pyrite, and sericite, are also present. The garnets occur in well-formed dodecahedrons containing inclusions of ilmenite and leucoxene. The biotite is light brown in color and in some specimens is largely altered to chlorite. The feldspars are extensively kaolinized, contain inclusions of biotite and chlorite, and in places show albite twinning.

This strip of foot-wall rock was encountered at the Bowles and Scotia mines as well as at the Tellurium. Pieces of vein quartz were found on the dump at the Bowles mine with some of the foot-wall adhering, which contained garnets over 1 cm. in diameter, partly imbedded in the vein quartz and partly in the wall rock.

At the Scotia mine dark green hornblende is found in places where the vein quartz, containing feldspar, occurs in contact with the rock underlying the quartzite. Occasionally small veinlets extend from the quartz vein out into the country rock and these carry much feldspar, white to yellow in color. The hornblende is present in the wall rock close to the vein, sometimes being the chief constituent, and does not seem to extend farther than 3 or 4 inches from the contact with the vein. This hornblendic rock grades into the normal biotite-chlorite-garnet schist described above. Examined microscopically (Spec. 143-B) the hornblende is light green to colorless, and shows alteration to chlorite and epidote. Quartz occurs in irregular grains showing optical distortion. Much titanite is present in clear, light pink to colorless grains, well-formed crystals of rutile occur as inclusions in the quartz, and ilmenite is also a minor constituent. Both rutile and ilmenite show partial alteration to leucoxene.

A specimen (194) of the rock underlying the narrow strip described above was obtained in the face of the northeast drive from the Tellurium incline shaft (*E* in fig. 12). It is a light brown schist similar in mineral composition to the overlying rock, except that it is finer grained and more siliceous. The minerals present are quartz, biotite and chlorite, garnet, feldspar, sericite, pyrite, leucoxene derived from ilmenite, and titanite, the order given being that of relative abundance. The quartz grains are small and show little optical distortion. Biotite is present in brown flakes containing occasional inclusions of quartz, and is extensively altered to chlorite. The garnets are light pink in color and show slight alteration to chlorite along fractures. They contain numerous inclusions of quartz, pyrite, and ilmenite partly altered to leucoxene. The feldspars—orthoclase and acid plagioclase—are extensively kaolinized.

The "Middle" vein is conformable in strike and dip with the enclosing schists, and therefore parallel to the quartzite bed. It is extremely variable in width, consisting of a series of small lenses which range up to 3 feet or more in thickness; and these lenses are all strung out along the same line, being usually connected by a narrow stringer. (See fig. 13.) In this respect the "Middle" vein is markedly different from the veinlets in the

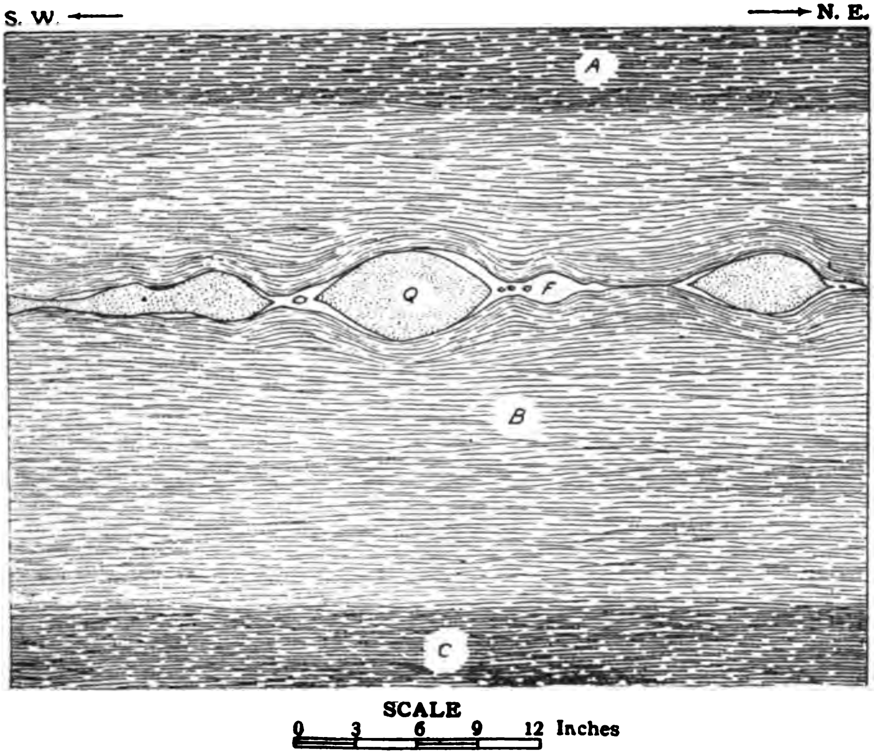

Fig. 13.—Diagrammatic sketch showing symmetrical lenses of the middle vein at the Tellurium Mine. *Q*, quartz; *F*, feldspar; *A*, hanging wall schist; *C*, foot-wall schist; *B*, bed of light-colored schist.

quartzite, for the latter are seldom lenticular in shape, frequently cut across the bedding of the enclosing rock, and are variable in their strike and dip.

The lenses forming the "Middle" vein are separated in places by a distance of several feet, and the veinlets connecting them may pinch to almost nothing so that only a faint line remains, but it can usually be distinguished without difficulty. In the partly decomposed schists near the

surface this line is marked by the dark stain of oxides of iron, probably from the alteration of pyrite; and when the soft material is broken away a little coarse grit, due to the presence of quartz, can be detected on the line. Feldspar is an important constituent of this vein, but in the openings that are now accessible it is completely altered to kaolin. The kaolin

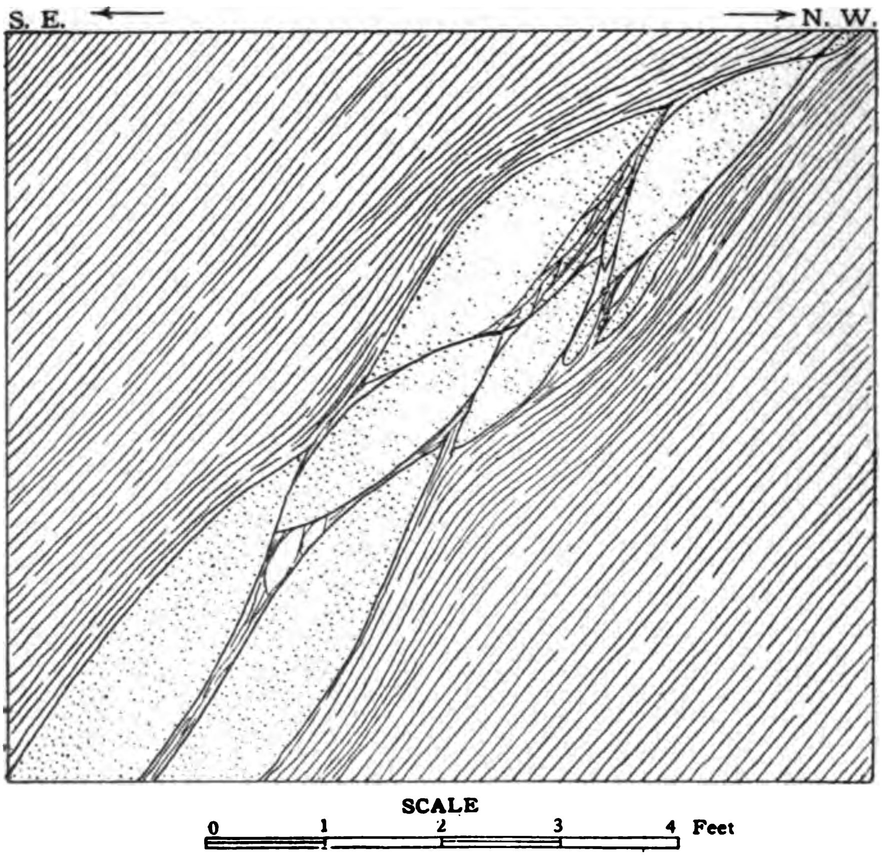

Fig. 14.—Vertical section of middle vein at the Tellurium Mine, showing large lens composed of smaller lenses.

occurs in small angular shapes distributed throughout the quartz, but is mostly found along the border portion of the lenses, and especially at points where they narrow and pinch out. (See fig. 13.) Some of the smaller lenses 2 or 3 inches in length are composed entirely of kaolin. In places the larger lenses are made up of a number of smaller ones as shown

in fig. 14, and where this occurs there is occasionally a little schist included between the component lenses. At one point the vein is cut by a vertical fault which displaces the vein about 2 feet. (See fig. 15.)

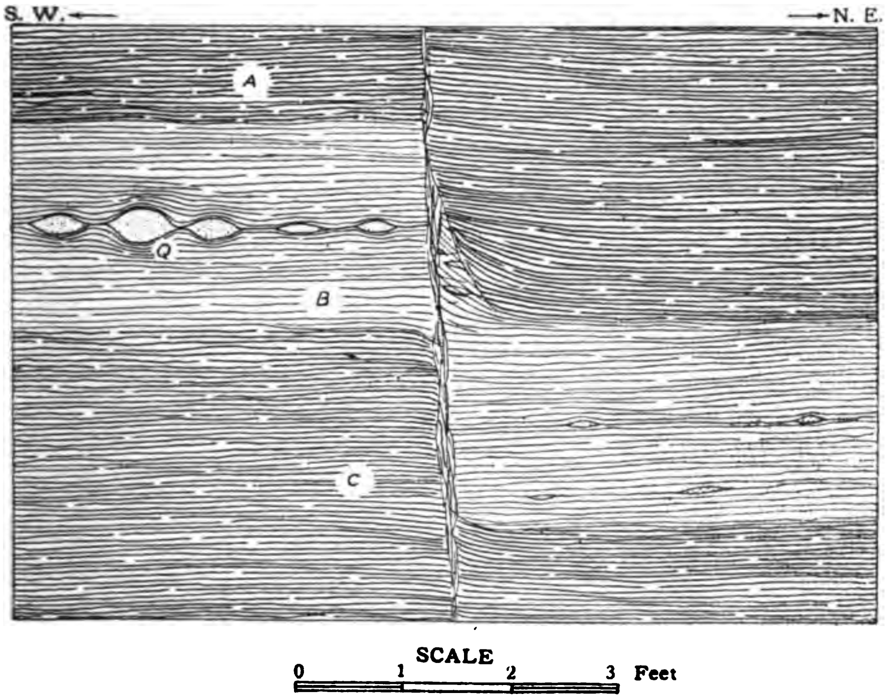

Fig. 15.—Vertical section showing symmetrical lenses of the middle vein of the Tellurium Mine, and a small fault. *Q*, quartz-feldspar lenses; *A*, hanging wall schist; *C*, foot-wall schist; *B*, bed of light-colored schist.

The formation of the peculiar lenses which constitute the "Middle" vein is discussed in detail in the chapter on genesis, pages 224-230, and therefore nothing further concerning them will be said here.

The "Middle" vein is similar in mineral composition to the veinlets that cut the quartzite bed and constitute the chief gold-bearing portion of the "Big Sandstone" vein, but it probably contains a larger percentage of feldspar. According to report, the "Middle" vein is much richer in gold than the "Big Sandstone," and this is unquestionably true if the whole bed of quartzite is included with the veinlets, but it is questionable whether the average value of the gold-bearing veinlets that occur in the quartzite is greatly below that of the "Middle" vein. An average sample,

taken across a lens in the vein 2½ feet wide, yielded $2.07 gold per ton, but it should be understood that this does not represent the average value of the vein. The best ore seems to occur in pockets or shoots, and much of the ore that has been stoped out unquestionably carried high values in gold. An ore pile on the surface showed much gold when tested by panning, and specks of visible gold are not infrequent in fragments of the ore. The wall rocks apparently are not mineralized to any appreciable extent.

The "Middle" vein is enclosed in a series of fine-grained, knotted schists, containing pseudophenocrysts of garnet. The folia of the schists in the immediate vicinity of the vein are wrapped around the lenses, conforming to every curvature of the ore-body, but in passing away from the vein the flexures gradually disappear, and at a short distance the folia are straight and undisturbed. (See fig. 13.)

The vein appears to follow a bed of light-colored schist 2 to 2½ feet thick interbedded with darker schists. Where exposed these rocks are so badly altered that it is not possible to obtain material sufficiently fresh for microscopic examination. The light-colored schist is composed essentially of quartz and sericite, with small, scattered brown spots due to the alteration of garnet. Along fractures and joint planes it is stained with iron, but elsewhere it is almost white in color. The overlying schist is light bluish-gray, and contains decomposed garnets 3 or 4 mm. in diameter, embedded in a fine-grained ground-mass. The folia of the schist are wrinkled or folded to form lenticular eyes around the garnets. The underlying schist is similar to the one last described excepting that the garnets are less numerous and smaller in size.

Pieces of unaltered garnetiferous schist, similar to the decomposed schist described above, were found on the dump of the 136-foot vertical shaft sunk in the hanging wall of the Tellurium veins. In the hand specimen (178) it is a thinly foliated, fine-grained, bluish-gray rock with high luster on surfaces parallel to the schistosity, and is spotted with numerous garnets in well-formed dodecahedrons 1 to 2 mm. in diameter. With the aid of a pocket lens, quartz, sericite, and biotite may be identified as the chief minerals of the ground-mass. Under the microscope the garnets are seen to be full of small inclusions consisting of grains of quartz, ilmenite partly altered to leucoxene, and a black opaque mineral in dust-like particles, possibly ilmenite. The ground-mass is composed of small irregular grains of quartz, with flakes of sericite, biotite, and chlorite, all of which are crowded with the black dust-like inclusions. Leucoxene is plentiful in grains which frequently contain nuclei of unaltered ilmenite.

Occasionally the garnets are partly or wholly surrounded by a zone from which most of the minerals other than quartz have disappeared, probably entering into the composition of the garnet; and the quartz has recrystallized into small, elongated grains, with their longer diameters oriented in approximate alignment with radii extending from the garnet. (See Pl. V, fig. 2.)

Pieces of rock, evidently igneous in origin, were found on the dump of an old shaft, which was sunk in developing the "Big Sandstone" vein at the Tellurium mine, but is now completely caved. In the absence of chemical analyses or knowledge of the structural relations, it is impossible to definitely classify this rock, but it is not improbable that it is genetically related to the granite on the northwest. In the hand specimen (185) the rock is light gray in color, fine-grained, and very schistose. Roughly formed, reddish-brown garnets and small flakes of biotite can be distinguished in a white ground-mass composed of quartz and feldspar. Examined in thin section, feldspar phenocrysts are seen, ranging up to 2 mm. in length, which, with flakes of biotite about 0.5 mm. in length and irregular garnets, occur in a fine-grained ground-mass composed of quartz, feldspar, biotite, a little sericite, and inclusions of leucoxene, zircon, titanite, and rutile needles. The feldspars are acid plagioclase (albite-oligoclase (?)) and orthoclase, the larger individuals have very irregular outlines, and they contain numerous fluid-filled cavities and small inclusions of zircon and the titanium minerals.

A different appearing igneous rock found on the same dump is much more schistose than the one previously described, and may represent an interbedded acid extrusive, or a dike rock older in age than the granite and its differentiates. It contains numerous garnets 1 to 2 mm. in diameter and flakes of biotite, embedded in a light brown, schistose ground-mass, composed essentially of feldspars, more or less kaolinized. Examined under the microscope the garnets are very ragged in outline and contain numerous inclusions of quartz. Feldspars, chiefly soda plagioclase, are dominant in the thin section, though a little orthoclase is present. Some of the larger feldspars are bent and broken, the fractures being filled by minerals of later crystallization. The minor constituents are quartz, pyrite, and leucoxene.

The hypothesis that these rocks are genetically connected with the granite is strengthened by the presence on one of the dumps of hornblendic schists, such as are found in the immediate vicinity of granite throughout the area. A hand specimen (179) of hornblende schist found

on the dump of the 136-foot shaft at the Tellurium mine, consists of coarse-bladed crystals of dark green hornblende ranging up to 1.5 or 2 cm. in length, and white, fine-grained quartz and feldspar. Small grains of pyrrhotite, pyrite, and magnetite are plentifully distributed throughout the rock. Under the microscope the hornblende is ragged in outline, and micropoikilitic in texture from numerous inclusions of quartz, magnetite, and pyrite. The cleavage is well developed and they are usually dark green in color, though some are nearly colorless. The quartz occurs in small rounded grains and is difficult to distinguish from the unstriated feldspar. The latter is acid plagioclase; probably no orthoclase is present in the rock. Magnetite is plentiful in small idiomorphic grains. Calcite and fibrous serpentine occur as vein-filling in a microscopic fracture.

Another variety found on the same dump is much finer grained. It is a greenish-gray schistose rock (Spec. 180) in which quartz, hornblende, magnetite, pyrite, and a little sericite can be distinguished with the aid of a pocket lens. In thin section the hornblende occurs, partly in dark green to colorless crystals with well-developed cleavage and strong absorption in the darker varieties, and partly in nearly colorless needles often clustered together in radiating groups. Quartz and an unstriated feldspar, probably acid plagioclase, are present in rounded grains showing little optical distortion. Much magnetite, in idiomorphic crystals ranging up to 1 mm. in diameter, is plentifully distributed throughout the rock.

The lenticular bed of ferruginous quartzite, known as the "Hodges" vein, which has been developed to some extent at the Scotia mine, is situated about 600 yards southeast of the course of the "Big Sandstone" vein. The few exposures in the vicinity indicate that the quartzite is interbedded with quartz-sericite schists. A small prospect pit, located about 300 yards northeast of the openings on the "Hodges" vein and approximately in line of strike, exposes a thinly foliated schist, which in the hand specimen (211) appears to be composed entirely of sericite and quartz. It is white in color when not stained with limonite, and contains occasional eyes of light blue opalescent quartz about 0.5 cm. in length. The strike of the schistosity is N. 60° E. and the dip 30° toward the southeast.

The shape of the quartzite bed, where it is exposed by short drives from the bottom of the incline shaft, is shown in fig. 16. The maximum width is over 6 feet, and from this the bed tapers down to a fraction of an inch at either end. The average dip is southeast 35° and the strike about N. 40° E. Although the quartzite apparently pinches out at either end of the lens, much float rock identical in appearance and composition occurs on the

surface about three-quarters of a mile northeast, and at several other points in the same general alignment.

Megascopically the quartzite is fine-grained, even-granular, and somewhat variegated in color because of local concentration of the various oxides of iron. In places the rock is white to light gray in color, consisting chiefly of quartz, with only a small amount of iron in the form of specular hematite and octahedral crystals of magnetite. Elsewhere the rock is dark brown

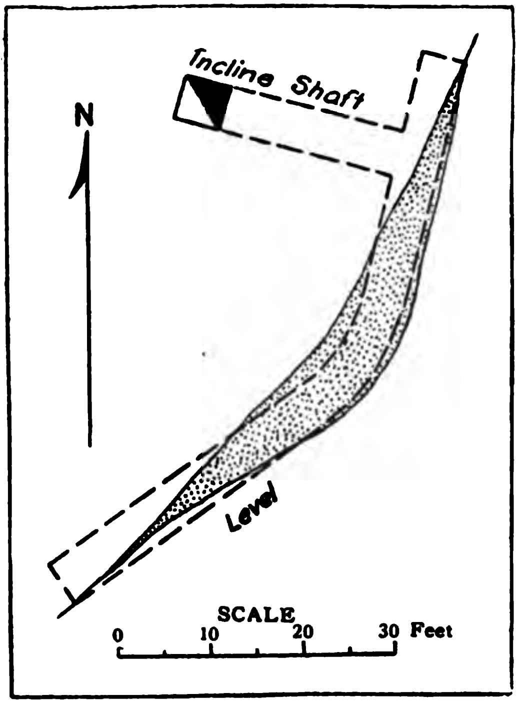

Fig. 16.—Horizontal plan showing lenticular shape of ferruginous quartzite bed exposed in underground openings at the Scotia mine.

to black in color and contains a larger percentage of the iron minerals, which are usually extensively altered to limonite. The two colors are irregularly intermixed, blotches of white being enclosed in areas that are dark brown in color and *vice versa*. Near the center of many of the dark areas, much fine-grained magnetite is found, and along the contact between the light and dark areas there is often a narrow, red-colored band, probably due to iron stain on the quartz grains.

In thin section (Spec. 153) under the microscope the rock is essentially the same as the non-gold-bearing ferruginous, quartzites which occur at a large number of localities in the area, described in detail on pages 19-22. The quartz grains are roughly rounded, nearly uniform in size, averaging about 0.25 mm. in diameter, and show no optical distortion. This close interlocking texture is due to recrystallization, which probably resulted in some enlargement of the individual grains. Small idiomorphic inclusions of martite (magnetite altered to hematite) are present in the quartz; and the larger masses of iron ore, occurring between the quartz grains, show considerable alteration to limonite, which in many places stains the boundaries of the other minerals. Zircon and a few small rutile needles are unimportant minor constituents.

The quartzite is cut by occasional irregular stringers of quartz, which range up to 10 inches or more in width, and very rarely contain vug-like cavities lined with quartz crystals. The stringers occur mostly on the foot-wall side of the quartzite. They carry a little pyrite largely altered to limonite, and probably a small amount of feldspar, though the latter mineral was not positively identified. The presence of gold is easily detected by panning, and sometimes small specks of free gold can be identified in hand specimens, usually in association with limonite derived from pyrite.

Tests made by panning indicate that the quartzite away from the gold-bearing veinlets carries little if any gold. Sometimes a small amount of pyrite may be found in the quartzite near the veinlets, but most of it occurs as a coating along fractures and is evidently secondary in origin.

The Scotia Mine.

Location.—The Scotia property is situated about half a mile north of Caledonia and 7 miles northeast of Columbia. It adjoins the Tellurium mine and is crossed by the southwestern extension of the same vein system.

History and description.—This property was formerly known as the Perkins mine and under that name was prospected in the early days of gold mining in Virginia. According to Credner the ore used to pay the working expenses. After 1849 very little work was done until the Scotia Mining Co. began prospecting in 1910. An account of the development work is given below and a detailed description of the veins and country rock will be found on pages 157 to 172.

A drain tunnel was driven 105 feet in a direction S. 11° E., cutting the "Big Sandstone" vein near the portal and also two small stringers that were called the "Middle" and "Little" veins. The country rock is much decomposed, but where fresh enough for identification consisted of

knotted garnetiferous schists similar to those at the Tellurium mine. A 67-foot vertical shaft sunk in the hanging wall, cut the "Big Sandstone" vein near the bottom. It was partly filled with water when the property was examined by the writer, but much fresh rock was exposed on the dump and this is described, together with the veins of the Tellurium system, on pages 157 to 164. The "Big Sandstone" vein was exposed in a pit sunk on the outcrop 100 feet northwest of the vertical shaft. Here the quartzite bed had a strike of N. 50° E., a dip of 35° southeast, and varied from 8 inches to 3 feet in width, averaging about 18 inches. It is cut by veinlets of massive white quartz carrying considerable kaolinized feldspar. The same vein has been prospected on this property by several other surface cuts.

An old incline shaft near the western boundary of the property was reopened by the Scotia Mining Co. It was sunk on a vein called the "Middle" vein, which has a maximum width of 2 feet about 12 feet from the surface and pinches to an inch near the bottom, 25 or 30 feet from the surface. The strike is approximately N. 60° E. and the dip 35° southeast. The enclosing rock, consisting of knotted, garnetiferous schist, is conformable in strike and dip, and is cut by vertical joint planes, spaced 12 to 18 inches apart, which have a strike of N. 44° W. It is improbable that this vein is continuous with either of the stringers in the drain tunnel or with the "Middle" vein at the Tellurium. Small stringers like these are not as a rule continuous for great distances but pinch out and are replaced by others a little farther along the line of strike.

Near the southwestern corner of the Scotia property there is a bed of ferruginous quartzite cut by small gold-bearing stringers, which is known as the Hodges vein. It has been developed by several surface cuts and an incline shaft on the vein, 43 feet deep, from which short drives were run in northeast and southwest directions. A detailed description of the ore and country rock is given on pages 170-172.

Gold Prospects Southwest of the Scotia Mine.

Passing southwest along the strike of the Tellurium vein system, old prospect holes are found at short intervals as far as Big Byrd Creek, but, while gold has been found at a number of these places, very little development work has been done.

On the Jennings tract adjoining the Scotia there are several old shafts and surface pits located along the strike of the Tellurium veins, but these are now caved and do not seem to have reached a depth of more than 40

feet. Knotted garnetiferous schist, having a strike of N. 60° E. and dip of 30° southeast, is exposed in one of the openings, and quartzite similar to that at the Tellurium mine is present on one of the shaft dumps.

By means of surface cuts, the quartzite bed has been traced across the Mosby, Fountain, and Cocke properties, and placer gravels have been worked along the branches that run through them and enter Big Byrd Creek. It is said that the "Big Sandstone" vein was prospected on the Fountain property in 1837 by Geo. Fisher, and another vein, known as the Marks vein, was also opened and worked to some extent. The ore was crushed in a small 3-stamp mill on Horsepen Creek and yielded $75 per day.[a]

Some mining has also been done on the old Bartlett place in this vicinity. Gold was discovered in the Bartlett Branch, which enters Big Byrd Creek from the east a short distance above Bowles' bridge, and the placer gravels are said to have been worked by the Fishers. Later the Bartlett vein was discovered and prospected and a little mining done. The ore from this vein was carried to Bowles' Mill on Big Byrd Creek and crushed in a small wooden stamp mill operated by the same power that ran the grist mill.

Recently some prospecting has been done on a part of the old Payne farm, now known as Cassell's mine. The place is situated on the county road about 2 miles northwest of Caledonia and 3 miles southwest of Kent's Store. A small amount of ore has been mined and milled but all the work has been of a superficial nature. Several shafts and cross-cuts, all above water level, have been sunk in decomposed rock, and the only veins exposed when the openings were examined by the writer, consisted of a few quartz stringers less than an inch in width. Part of the workings are in a decomposed dike-like rock about 20 feet wide which appears to be pegmatite. It is not well exposed but has a probable strike of N. 6° E.

Close to the other openings a pit has been sunk on a highly ferruginous quartzite bed 8 feet or more in thickness. The quartzite is dark brown with occasional light-colored spots, and is cut by closely spaced joints. It is composed of fine-grained quartz, hematite, and a little magnetite, and the light spots seem to be due to recrystallization of silica. In places along cracks or cleavage planes a crust of magnetite has been formed consisting of crystals 2 to 3 mm. in diameter. The quartzite is cut by quartz veinlets 1 to 2 inches in width which frequently contain plates of micaceous

[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, pp. 42-43.

hematite. Examined under the microscope (Spec. 209) it seems to have undergone greater recrystallization than the other ferruginous quartzites of the area. The quartz grains lack uniformity in size and are irregular in outline; they usually show optical distortion and contain comparatively few inclusions of the iron ores, while the larger masses of hematite contain small inclusions of quartz. The iron ores are partly altered to limonite, and the latter in places stains the contacts between the quartz grains.

The Bowles Mine.

Location.—The Bowles property is situated 1½ miles southeast of Tabscott and about 8 miles northeast of Columbia. It lies east and northeast of the Tellurium mine, and embraces a large area of land in both Goochland and Fluvanna counties.

History and general description.—The placer gravels along the two branches that run through the property were extensively worked for gold prior to the Civil War. After the veins of the Tellurium system had been developed on the property of that name, they were traced across on to the Bowles tract and prospected at several points. Prospecting has been renewed at several different periods and considerable development work carried out. A shaft started on the outcrop of the "Big Sandstone" vein was sunk about 100 feet on the dip of the vein, and 50 feet from the collar a cross-cut was driven southeast to connect with a vertical shaft at a point about 40 feet below the surface. The vertical shaft was sunk to a depth of 72 feet, and after striking the "Little" vein was continued for 45 feet along the dip of the vein. When visited by the writer in 1910 the shafts were partly filled with water and all the workings inaccessible. The data given above were furnished by Mr. Ferris, who was in charge of the property at the time. The character of the veins and the structural relations of the wall rock, which are the same as at the Tellurium mine, are described in detail on pages 157 to 172.

The Gold Hill vein system crosses the northwestern end of the Bowles property, and several of the veins belonging to it were prospected at an early date. A number of shafts and other openings have been made, but practically all of them are now caved. The most extensive workings are located on the Gold Hill vein, and the Shaw or Back Field vein. Ores from the former vein were hauled to the Tellurium mill for treatment when mining was in progress about 25 years ago. A little work has been carried on recently by Mr. Ferris, who mined a few tons of high-grade ore from a small opening on the Back Field vein and crushed it in the Tellurium mill. The veins belonging to the Gold Hill system are described in detail below.

The Gold Hill Vein System.

Introduction.—The Gold Hill vein system is situated about 2 miles southeast of Kent's Store and 2 miles west of Tabscott, and extends for a mile or more in a general northeast-southwest direction. It consists of a series of small veins, which show a greater variation in strike and dip than is found elsewhere in the district, but none of them seems to be very persistent. The veins have been developed to some extent at several places on the Bowles, Shaw, and McGloam properties, but all the work has been rather superficial in its nature. These veins differ from other veins of the district in several important characteristics besides their lack of uniformity in strike and dip. They are located in an area of fine-grained granite, and are the only known gold-bearing veins within this district that occur in granite. The veins are characterized by the presence of coarsely crystalline pyrite, which frequently occurs in large cubical shapes 1 cm. or more in diameter.

Country rock.—There are few exposures of the country rock except where openings have been made in prospecting the gold veins. The dominant rock is a fine-grained granite, and this contains areas of hornblende and chlorite schists, which are more noticeable near the border portions. Because of the extensive decomposition of the rocks in this section it is not possible to accurately map the boundaries of this granite area, but it has a width of more than one mile, and extends for an unknown distance in a northeasterly direction, probably connecting with the main granite batholith that lies to the east.

The granite where freshest is a light gray, fine-grained rock, with scarcely any schistosity. The minerals visible to the naked eye are quartz and feldspar, with numerous small flakes of dark green chlorite, a little sericite, small cubes of pyrite, and occasional grains of magnetite. In thin sections it varies from granitic to granophyric in texture, intergrowths of quartz and the feldspars being common, and in places very abundant, while small phenocrysts of feldspar are present in some of the rock. The feldspars are acid plagioclase and orthoclase, with sometimes a little microcline. The white mica is apparently all secondary, and frequently shows intergrowths with quartz. The chlorite is probably derived from biotite, a mineral which is present in small quantities only. Calcite is plentiful in some slides and is probably derived chiefly from the feldspars. The minor constituents occurring in the rock are zircon, leucoxene, apatite, and rutile needles, while fluid inclusions are numerous in some of the quartz grains. (Specs. 82, 83, 158, 161, and 166.)

The hornblende schist is exposed at several points in narrow bands interleaved with granite, and also in areas at least several hundred feet across. These schists are similar to the corresponding schists in the larger granite area, and are doubtless the same in origin. The rock is dark green in color and varies from medium coarse- to fine-grained. Hornblende, often largely replaced by chlorite, quartz, and feldspars, are the chief constituents; pyrite and magnetite can usually be recognized megascopically; and in some of the rock small grains of rutile and ilmenite can be identified. Under the microscope the larger hornblendes are ragged in outline and micropoikilitic from numerous inclusions of quartz and magnetite. The feldspars (acid plagioclase) are clear, unstriated, and difficult to distinguish from quartz except by their lower index of refraction. Occasional grains of titanite, inclusions of zircon, and small rutile needles constitute the minor accessories. (Specs. 80, 81, 159, 160, 165, and 167.)

Granite is the principal rock composing the dumps from shafts sunk on veins belonging to this system, and the hornblende schist is present in smaller amounts or entirely absent.

The McGloam mine.—The McGloam mine is situated half a mile north of the Tellurium and joins the Bowles property which lies to the east. There are 2 shafts on the property 300 yards apart, one vertical and the other on a flat incline, but both are now filled with water. A vein, 1 to 2 feet wide, is exposed in the mouth of the incline shaft. It has a strike of N. 70° E. and dips southeast at an angle of 30°. The fine-grained granite, a little hornblende schist, and considerable vein quartz are present on the dump.

The vein quartz contains much coarsely crystalline pyrite, and in some pieces this has been partly or wholly removed, leaving cavities in the quartz which frequently show no staining from oxides of iron. A little free gold can sometimes be detected by panning. In places the vein quartz is interleaved with narrow bands of fine-grained granite which in the hand specimen resembles quartzite, for it contains practically no ferromagnesian minerals. A thin section (162) examined under the microscope, contains a veinlet of quartz 3 mm. wide enclosed by granite. The veinlet has sharply defined boundaries and is composed of quartz, containing numerous fluid inclusions, a very little feldspar, and some sericite. The enclosing rock is granitic to granophyric in texture, and consists of irregular rounded grains of quartz and feldspar, with a fine intergrowth of feldspar and quartz filling the interstitial spaces. The feldspar is chiefly acid plagioclase, usually showing albite twinning, but orthoclase is also present and

occasionally forms Carlsbad twins. A few flakes of sericite, small, scattered grains of magnetite, inclusions of zircon, and minute rutile needles make up the minor accessory minerals. A piece of granite found on the dump was cut by a stringer of quartz 1 inch in width, which contained small vugs lined with quartz crystals.

Fine-grained granite and vein quartz were found on the dump of the vertical shaft, but no hornblende schist. The vein quartz (Spec. 162) contains coarsely crystalline pyrite, and angular inclusions and irregular streaks of the country rock. The inclusions, which are often large, give to the weathered rock the appearance of pegmatite. They are composed essentially of fine-grained feldspar and quartz which under the microscope are seen to be closely intergrown. The vein quartz shows little optical distortion and contains numerous fluid inclusions, usually arranged in long, broken lines which may pass without interruption from one individual to another.

The Shaw mine.—The Shaw property is situated 1½ miles northeast of the Tellurium mine, and on the east side of the northern portion of the Bowles tract. There are several shallow shafts located close to the small branch which passes through the property, but they are now partly caved and filled with water. They are said to have been sunk on the Shaw vein which has a strike of N. 80° E. Granite and hornblende schist were found on the dump, and the former rock outcrops at several places in the vicinity.

The Bowles mine.—The Bowles property is described on page 175, and therefore only the veins belonging to the Gold Hill system will be mentioned here.

Near the northern end of this property there are several pits and small shafts, which are said to have been sunk on the "Shaw" vein, or "Back Field" vein as it is sometimes called. Only one of the openings was accessible when the property was examined by the writer, and this was not over 30 feet in depth. The vein where it is exposed varies from 1 foot down to a fraction of an inch, but Mr. Ferris, who was in charge of the property, states that in places it attains a width of 4 feet. The strike is about N. 60° E. and the dip 30° southeast, so it is hardly probable that this vein is the extension of the one opened on the Shaw property. In places the vein carries considerable pyrite, partly altered to limonite, and at such points it is said to be rich in gold. A specimen examined by the writer contained grains of gold 2 mm. in diameter. Some of the vein quartz found on the dump contains cavities, evidently left by the oxida-

tion and removal of pyrite, for some of them are partly filled with limonite; and attached to the walls of these cavities are numerous octahedra of magnetite 1 mm. and less in diameter. The wall rock where exposed consists of kaolin and quartz stained with a little iron, and is undoubtedly residual decay from the fine-grained granite found elsewhere in the vicinity.

About 500 yards south, a vein 1 foot in width is exposed by a small pit. It has a strike of N. 22° E. and is nearly vertical. The quartz contains coarse cubical crystals of pyrite similar to those found in the other gold-bearing veins in this granite area. Between this point and the McGloam vein numerous openings have been made, but they are not in perfect alignment and the veins which were prospected seem to have different courses. The greatest amount of development work was done at a point where the Gold Hill vein, running northeast-southwest, is said to be intersected by the "Cross" vein. There are several shafts and pits now caved along the course of the latter vein, which has a strike of N. 30° W., and is said to dip southwest at an angle of about 35°. This work was done many years ago and little is now known concerning these veins. A piece of quartz containing small prisms of black tourmaline was picked up near the outcrop of the "Cross" vein.

The Page Mine.

The Page mine is located in Fluvanna County on Long Island Creek a mile west of Wilmington. The veins on this property were first mined in 1856 and an 8-stamp mill was built to crush the ores.[a] According to Credner the ore was derived from 2 quartz veins, carrying fine-grained galena and gold, which were opened by several tunnels and shafts.[b] The mill was in ruins at the time of his visit in 1865. It is reported that prospecting was renewed about 1895, but no mining seems to have been done.

When the property was visited by the writer in 1911 the only accessible opening was a tunnel about 20 feet long which ran under the hill on the west side of the creek. The country rock exposed in the tunnel is a partly decomposed slate but no vein could be seen. Most of the work was done on the east side of the creek where there is an old caved tunnel, and on the hill above it several pits and open cuts. No rock was exposed on this side of the creek, but on the tunnel dump large pieces of vein quartz were found and some of them contained inclusions of chloritic slate, and narrow, irregular veinlets of calcite.

[a]Nitze, H. B. C., and Wilkins, H. A. J., Gold Mining in North Carolina and Adjacent Appalachian Regions, Bull. 10, N. C. Geol. Survey, 1897, p. 75.
[b]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, pp. 42-43.

The gold-bearing gravels along Long Island Creek and some of its tributary branches have been worked, and gold nuggets worth $20 to $25 were found on one of the properties a short distance up the creek from the Page mine.[a] Placer mining is said to have been carried on as late as 1865.

About 1½ miles up stream from the Page mine there are several openings and a tunnel 100 to 200 feet in length which are said to have been made by Commodore Stockton. Credner states that a series of lenticular quartz concretions were exposed by an incline on top of the hill. The ore was a very hard, sandy quartz, carrying free gold in minute particles. Another quartz vein, nearly 60 feet wide, was exposed by prospecting pits but the ore was very poor.[b]

On several properties lying 1½ to 2 miles north of Wilmington a little gold has been found in the placer gravels along the branches, and some quartz veins in that vicinity have been prospected by openings now caved, but all of the work seems to have been very superficial.

The Snead Mine.

Location.—The Snead mine is situated in Fluvanna County, 1 mile north of Fork Union, and is about 3 miles northeast of Fork Union station on the Virginia Air Line Railway.

History.—According to Credner the mine was first opened in 1838 and worked for nine months, during which time it yielded $6,000.[c] The ore was treated in a primitive stamp mill operated by water-power, and much of the gold is said to have been lost in the tailings. Hamilton states that the mine was worked until 1850.[d] The vein was opened by a shaft 25 feet deep, several open cuts along the outcrop, and a tunnel. An attempt to reopen the mine was made after the close of the war, and in 1881 the chlorination process of extraction was tried.[e] No work has been carried on for many years and the old workings are caved and inaccessible.

Geology.—The vein is located very close to the contact between the sedimentary rocks and the granite. On the west side of the vein near the

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[a] Credner, H., Op. cit.

[b] Credner, H., Op. cit.

[c] Credner, H., Op. cit., p. 58.

[d] Hamilton, J. R., The Natural Mineral Wealth of Virginia, *Harper's Magazine*, 1865, vol. xxxii, pp. 32-42.

[e] Hotchkiss, Jed., The Tellurium Mine and Virginia Gold Mining, The Virginias, 1881, vol. ii, p. 85.

branch that flows through the property, knotted schists are exposed that are identical with those in the bluffs at New Canton. The rock is bluish-gray, fine-grained, and contains pseudophenocrysts of garnet and biotite 1 to·1.5 mm. in diameter.

The granite on the east side of the vein is a medium-grained gneissic rock composed for the most part of feldspar and quartz, white to light gray in color, with large black blotches of biotite in small flakes. Under the microscope the soda-lime feldspars (oligoclase) are seen to be dominant over the potash feldspars (chiefly orthoclase). Some microperthite is present. Quartz occurs in irregular grains showing slight optical distortion and contains fluid-filled cavities, zircon, and rutile needles. The biotite is greenish-brown in color and shows strong absorption. Tourmaline occurs in occasional light brown prisms. Much carbonate, a little chlorite, and epidote are present as secondary minerals.

The vein is 3 to 6 feet wide and runs in a northeast-southwest direction, the dip being about 65° toward the east. Credner states that the vein consists of hard white quartz, "containing sulphurets of iron, copper, lead, and zinc, and also oxide of iron, phosphate of lead, carbonate of copper and free gold."[a] Hamilton mentions the presence of argentiferous galena.

The Hughes Mine.

Location.—The Hughes mine comprises a tract of 275 acres located in Fluvanna County on the Virginia Air Line Railway about 2 miles northeast of Fork Union station and 2½ miles southwest of Carysbrook.

History.—This mine was first opened in 1836, but for many years it changed hands frequently and very little development work was done. The last period of operation began about 1895 and continued until the spring of 1906, since which time the mine has remained idle. During this period the mine was developed by the Hughes Gold Mining and Milling Company to a depth of 115 feet, and an elaborate plant installed to treat the ore.

Equipment.—The surface equipment consisted of a double cylinder steam hoist at each of the 2 shafts, a boiler house, mill, and cyanide plant. The mill building contained 2 batteries of 5 stamps each, amalgamated copper plates, and 4 Frue concentrators. The concentrates which carried 60 per cent. of the values were roasted and the gold extracted by treatment with cyanide solutions, while the tailings from the stamp mill were cyanided raw. The extraction is said to have been over 90 per cent. and the cost

[a]Credner, H., Op. cit.

of mining and milling a little over $4.00 per ton. At present the mill is partly dismantled and some of the machinery has been removed.

Underground development and description of veins.—According to Mr. Bugbee, who was general manager for the Hughes Gold Mining and Milling Company, the underground development work has been limited to 3 veins, two of which strike in a northeast-southwest direction parallel to the country rock, while the third running in an east-west direction cuts across the rock formations and intersects one of the other veins. The figures given below were taken from a prospectus issued by the Hughes Gold Mining and Milling Company in 1905.

Shaft No. 1 was sunk to a depth of 40 feet on the larger vein, a level was driven from the bottom of the shaft 140 feet southwest along the vein, and more than 50 feet of ore above this level has been stoped and milled. A mill run on 585 tons of this ore is said to have given a gross value of $9.00 per ton. The vein has been proved by surface pits for 1,500 feet along the strike and has an average width of 2½ feet.

Shaft No. 2 was sunk to a depth of 110 feet on a second vein about 800 feet southwest of the first, and levels were driven at depths of 60 and 110 feet, respectively. From these levels cross-cuts were driven to reach the third vein 128 feet from the shaft. The second vein has been stoped out from the 60-foot level to the surface. It averaged 1½ feet in thickness between the extremes of 1 and 3 feet, and the average value is given at $20.00 per ton. The third vein, which has been developed for 230 feet along its strike, varies from 1 to 4 feet in width, averaging 2 feet, and is said to be worth $13.00 per ton. In addition to the veins mentioned above 4 other veins have been prospected by surface pits and found to contain good values in gold.

Geology of veins and country rock.—At the time this property was visited the underground workings were filled with water and therefore inaccessible, so that it was not possible to examine the veins and wall rock in place. The ore found on the surface is chiefly vein quartz, varying from coarsely crystalline to saccharoidal in texture, and in places it contains much pyrite. Fine flakes of light green chlorite are frequently present in the quartz chiefly along fractures, and chloritic schist containing pyrite was found attached to some of the ore.

The wall rock, as indicated by material found on the shaft dumps, is a greenstone schist derived from an igneous rock, probably a diorite porphyry. In the hand specimen it varies from light to dark green and contains eyes of light blue opalescent quartz, ranging up to 0.5 cm. and

over in diameter. In thin section (Spec. 36)[a] the large quartz eyes show optical distortion and some granulation. Rutile needles are occasionally present as inclusions. The ground-mass is composed of soda-lime feldspars, quartz, chlorite, epidote, zoisite, sericite, and a little titanite. The minerals show the effects of mashing, and the feldspars are extensively altered to saussurite and chlorite.

With the exception of the veins belonging to the Gold Hill system, this is the only mine in the district where gold-bearing veins have been found in rock of igneous origin. A short distance west of the veins ferruginous quartzites occur which are similar to those found interbedded with the schists in many localities throughout the area. At several places on the property pieces of almost pure magnetic iron ore are present on the surface, and some specimens[b] were seen which have the appearance of a hematite breccia recemented with magnetite and hematite. The magnetite occurs in masses that are composed of small grains and octahedral crystals ranging up to 2 mm. in diameter.

MINES IN BUCKINGHAM COUNTY.

The London and Virginia Mine.

Location.—The London and Virginia mine, or London mine as it is sometimes called, is located about a mile north of Dillwyn, a station on the Buckingham Branch of the Chesapeake and Ohio Railway. It joins the property of the Buckingham mine on the southwest.

History.—This property was first known as the Eldridge mine, and it was worked for a number of years by Mr. Eldridge before being sold to the London and Virginia Gold and Copper Mining Company, which was formed in London and incorporated in Virginia in 1853.[c]

At first most of the ore was derived from open cuts, which were carried to a depth of 20 to 40 feet, and extended for a distance of 150 yards along the outcrop. Later, shafts were sunk proving the vein to a depth of at least 150 feet, and underground mining was extensively carried on. Operations were being conducted at the same time on the adjoining property, known as the Buckingham mine, and the two mines were connected underground by a continuous drive along the vein.

The mill used by Mr. Eldridge to pulverize the ores was located some distance north of the mine and operated by water-power. This mill was

[a]This thin section was made from a specimen collected by Dr. J. S. Grasty.
[b]Specimens collected by the State Geologist, Dr. Thomas L. Watson.
[c]Whitney, J. D., The Metallic Wealth of the United States, Philadelphia, 1854, p. 128.

in operation for about 15 years, and Mr. Partz, in 1854, stated that there were at least 200,000 bushels of tailings lying on the ground, which could be advantageously worked over a second time.[a] Later a mill was built a few hundred yards southeast of the vein, and the pile of tailings, which remains to this day, is mute evidence of an industry long since suspended. The property was closed down 5 or 6 years before the Civil War, and since that date active mining has not been resumed, but it is said that the old piles of tailings have been reworked at a profit, and $10,000 extracted from them.

Descriptive geology.—The London and Virginia "vein," or "bed" as it has been variously called, has been opened up for practically the entire distance across the adjoining properties of the London and Virginia and the Buckingham mines, and there are numerous shafts and pits located along its line of strike for a distance of several miles. Since the greatest amount of development work has been done on the two properties above mentioned, and since the character of the ore and the structural relations of the enclosing country rocks are essentially identical wherever they have been observed; a single detailed description will suffice for both the London and Virginia and the Buckingham mines, and in the case of other properties located along the same vein only the variations from this description will be noted.

The London and Virginia vein is situated in a series of fine-grained schists and schistose quartzites, all of which are probably sedimentary in origin. The formation has an average strike of N. 40° E. and dips at a steep angle toward the southeast, in places being practically vertical. While there are few outcrops in the vicinity of the mines, the material on the dumps and the rocks exposed in the open cuts, which are almost continuous along the outcrop, together with the descriptions of the mines by Ansted, Henwood, and others, who examined them when they were accessible, furnish sufficient facts to make possible the drawing of general conclusions in regard to the character of the ore, and the relation of the ore deposit to the surrounding rocks.

Henwood states that "a rather fissile and somewhat contorted clay-slate, of homogeneous texture and leaden hue—the lowest rock observed in the neighborhood—is succeeded by a narrow band of whitish quartzose mica-slate, frequently interspersed with talc [probably sericite]; the auriferous deposit which succeeds is overlaid by thin lamellar greenish-white chloritic talc-slate [sericite-schist] now and then flecked with mica."[b]

[a]Partz, A., Examinations and Explorations on the Gold-Bearing Belts of the Atlantic States, Mining Magazine, 1854, vol. ii, p. 380.

[b]Henwood, W. J., Observations on Metalliferous Deposits, Trans. Royal Geol. Soc. of Cornwall, 1871, vol. viii, p. 376.

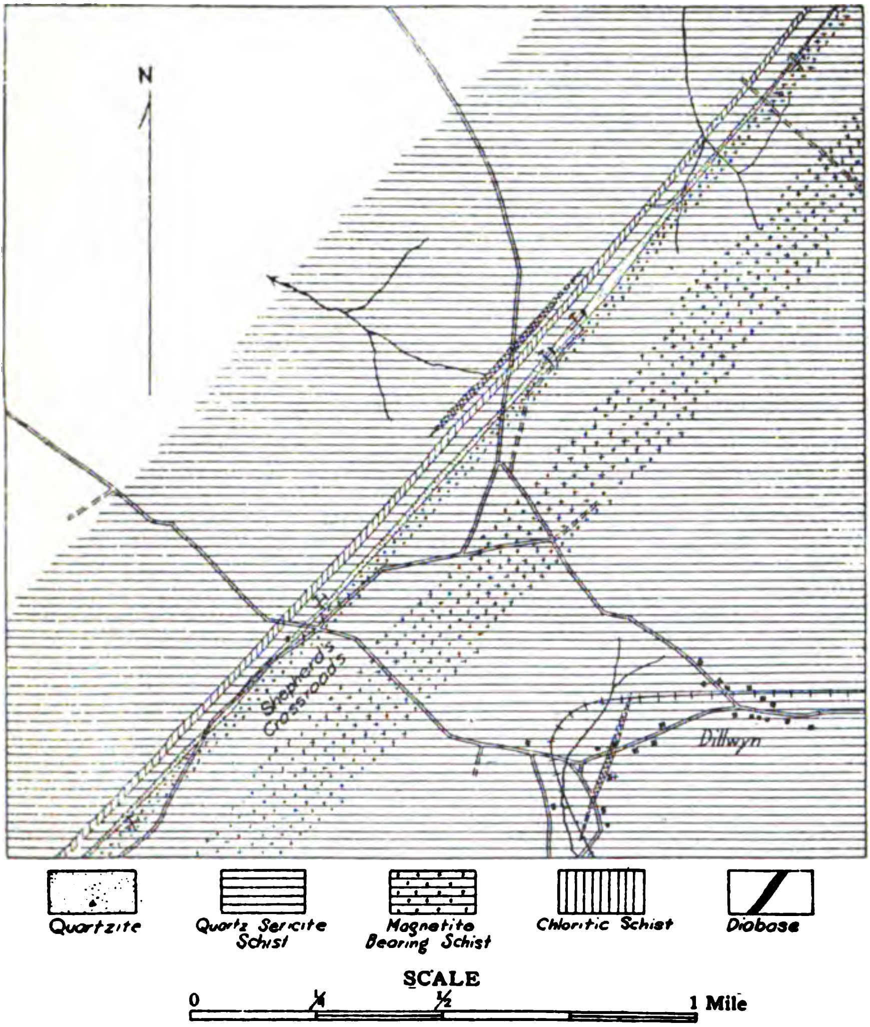

Fig. 17.—Sketch of map showing surface geology and location of mines and prospects along the strike of the London and Virginia vein, in the vicinity of Dillwyn.

A rock (Spec. 340) probably corresponding to the lead-colored slate mentioned above was found by the writer at the Buckingham mine, on the dump of a small pit which is located on the west side of the road crossing the property, and about 100 yards northeast of the outcrop of the vein. This rock is a chloritic schist varying somewhat in granularity but

usually fine-grained. The dominant type is a dark gray schist in which most of the minerals are too fine for megascopic identification. It is cut by frequent fracture lines along which a little epidotization has taken place. Sericite, quartz, and chlorite can be identified with the aid of a pocket lens, and the rock contains much fine-grained magnetite, a little pyrite, and is closely sprinkled with small pink garnets, less than 0.5 mm. in diameter.

Apparently the same chloritic schist as that just described crosses the road 125 yards northeast of Shepherd's Crossroads. While much weathered at this point the rock does not appear to be more than 50 or 60 yards wide. Northwest of this bed no exposures were found but the residual decay indicates that, for some distance, the country rock is for the most part a light-colored quartz sericite schist.

About 50 yards southeast of the rock described above, and 50 yards northwest from the outcrop of the vein, there is an old shaft or pit, now caved, but the dump contains some comparatively fresh rock (Spec. 341). It is a very fine-grained quartz-sericite schist, pure white in color, which breaks readily along the cleavage planes, exhibiting a bright lustrous surface due to minute flakes of sericite. The rock is cut in two or more directions by closely spaced joints that cut the planes of schistosity at an oblique angle. A few grains of opalescent quartz, 0.75 mm. in diameter, and very fine grains of pyrite are the only minerals that can be distinguished megascopically.

In thin section under the microscope the rock is seen to consist largely of small quartz grains, the spaces between them being filled with a clear colorless mineral without cleavage and having a much lower index of refraction than the quartz (probably albite or orthoclase feldspar). Small flakes of sericite occur, mostly segregated in separate bands. There are also narrow bands or veinlets of quartz, slightly coarser grained than the rest of the rock, and the frequent association of these with pyrite suggests that they may in part be due to the circulation of solutions, rather than to recrystallization without migration of the mineral particles. Gas- and liquid-filled cavities are present in the larger quartz individuals. The pyrite ranges up to 0.2 mm. or over in diameter, but most of it is much finer. A little titanite is present in small grains.

The quartz-sericite schist by decrease of sericite passes into a fine-grained schistose quartzite, which usually carries more or less sericite. In places the change from schist to quartzite is quite sharp, but the fact that the two rocks are contemporaneous and have had a similar origin

can not be doubted. In the vicinity of the vein both the quartzite and schist are heavily impregnated with pyrite.

West of the vein, the rocks in places contain much magnetite. Some of the quartzite carries fine-grained magnetite and hematite, and on the surface, near the outcrop of the vein, pieces of biotite schist were found which contained numerous well-formed octahedra of magnetite. This rock is fine-grained, dark gray to black in color, and is composed for the most part of biotite, quartz, numerous reddish-brown garnets, and, in places, much magnetite in perfect octahedral crystals about 1 mm. in diameter. In the different laminæ the proportion of these minerals varies somewhat and a little sericite may also be present. The rock is cut by a number of bands or veinlets of fine-grained quartz, which are usually parallel to the schistosity.

Southeast of Shepherd's Crossroads 150 yards, a fine-grained sericite schist outcrops in the road. It has a strike of N. 40° E. and dips steeply to the southeast. The rock is composed essentially of fine-grained white sericite with little if any quartz, and contains numerous small iron-stained cavities left by the oxidation and removal of pyrite or magnetite. For a distance of several hundred yards southeast of this point, while there are no exposures, much magnetite is concentrated on the surface, and it has probably weathered out from magnetite-bearing schists essentially similar to those already mentioned.

About 100 yards northwest of the vein, where it outcrops at the Buckingham mine, a diabase dike about 75 feet wide crosses the road in a northeast-southwest direction, but could not be traced for any great distance along the strike. A short distance west of the road a small pit furnishes exposures of the fresh rock. It is a coarse-grained, olivine-bearing rock, with marked ophitic texture. The feldspars are 3 to 4 mm. long and twinning is easily detected with the naked eye. It is unlikely that this rock has in any way influenced the ore deposits.

Description of vein.—Since most of the vein exposures have been rendered inaccessible through the caving of old workings it is not now possible to examine the ore-body in detail, but Henwood gives the following description:

"The metalliferous bed, conforming to the dissimilar flexures of the rocks on opposite sides, varies in width from 3 to 20 feet on the northeast, but 4 to 5 only toward the southwest. The northeastern portion consists, near the surface, of granular, massive, and cellular quartz; sometimes embedded in, but frequently mingled with, earthy brown iron ore. Traces of galena occur at intervals; and small drusy cavities often afford crystals

of the phosphate of lead and of selenite. The quartzose parts contain bodies of friable iron pyrites; of which the most deeply seated are the largest and most numerous. These . . . enclose isolated masses of copper-pyrites; invested occasionally with copper-glance, but more generally with earthy black copper ore.[a] The southwestern portions include many unconnected, angular blocks of slate; of all which the composition resemble, and the planes of structure conform to, the compositions and structures of the rocks in their respective neighborhoods. Except in this particular, and that massive quartz is more abundant, the southwestern parts differ but little from the northeastern. . . . The earthy brown iron ore and the quartz are slightly auriferous when separate; but when united in certain manners and proportions—more easily recognized than described—they frequently enclose small nuggets, thin plates, and crystalline grains, united by threads of gold; which constitute from 0.0000056 to 0.0000070 of the ore extracted."[b]

According to Partz the oxidized or "soft ores" extended to a depth of 20 to 40 feet "where the slate became hard and solid on account of the undecomposed auriferous pyrites in it";[c] and Ansted states that "about 80 feet down from the surface threads of copper ore were found consisting of copper pyrites mingled with iron pyrites which forms the staple."[d]

The sides of the old open cuts from which the ore was taken frequently furnish exposures of dark iron-stained quartzite, usually containing small cavities due to the removal of pyrite. At the Buckingham mine a large mass of this quartzite remains standing in the center of the opening, ore having been removed from either side, and the walls of the cut are of the same material. Where the surface has not been disturbed there are in places outcrops of quartzite in line of strike with the old workings.

The ore found on the dumps and in the vicinity of the mine which came from the deeper workings is mostly fine-grained, white quartzite with more or less disseminated pyrite. White quartz-sericite schist similarly impregnated with pyrite also occurs, but does not appear to be as plentiful at the Buckingham and London and Virginia mines, as at some other localities along the strike of the vein.

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[a]The following note is given by Henwood on page 376 of the publication previously cited:

"This ore afforded 0.230000 its weight of copper
0.001142 its weight of silver
0.000060 its weight of gold

Johnson and Matthey, Prospectus of the London and Virginia Company, p. 2."

[b]Henwood, W. J., Op. cit., pp. 376 and 379.

[c]Partz, A., Op. cit., p. 379.

[d]Ansted, D. T., The Alleghanies and the Gold District of Eastern Virginia in Scenery, Science and Art, London, 1854, p. 287.

A specimen (342) found on the dump at the Buckingham mine shows the quartzite in contact with the quartz-sericite schist. The quartzite is a white, fine-grained, even-granular rock, impregnated with fine crystals of pyrite; and a little sericite in minute flakes can be distinguished on fracture surfaces approximately parallel to the schistosity. The schist is composed of the same minerals as the quartzite, the difference being in their relative proportions; sericite is very prominent, though in this specimen quartz is probably the dominant mineral, and pyrite is more abundant than in the quartzite. The contact between the two rock types while slightly irregular is quite sharp, and makes an angle of about 40° with the schistosity of the rock. The pyrite is uniformly disseminated, except that it is more plentiful in the schist than in the quartzite, making up perhaps 10 or 15 per cent. of the former and not more than 4 or 5 per cent. of the latter.

In thin section under the microscope the quartzite is seen to be composed of small clear, interlocking grains of quartz showing no optical distortion, idiomorphic crystals of pyrite ranging from dust-like particles up to crystals 1 mm. in diameter, and a few flakes of sericite. Occasional scattered crystals of orthoclase and acid plagioclase may be observed, and in places interstitial space between the quartz grains contains a light brown or colorless to cloudy mineral which is isotropic, and has a low index of refraction. It is probably some variety of opal. The quartzite has undoubtedly undergone extensive recrystallization, and the pyrite which impregnates the rock is probably secondary, replacing some of the quartz.

Only a very little massive vein quartz can be seen on the dumps, but several pieces of quartzite were found cut by small veinlets of massive quartz, ranging up to several inches in thickness. One specimen (343) shows a vein of massive quartz, 2 to 4 inches wide, which contains feldspar, nearly white in color with a slightly pinkish cast, and difficult to distinguish at a glance from the quartz. The feldspars occur partly in single individuals 1 to 2 mm. in diameter and partly in clusters having an area of 2 cm. or more. Occasionally coarse multiple twinning can be distinguished with the naked eye. The quartzite and schist in contact with these veinlets are heavily impregnated with pyrite, but the vein quartz contains comparatively little of this mineral.

In addition to the minerals mentioned in the above descriptions, several others have been reported by various writers. Partz states that "in one pit we found several specimens of fibrous (asbestiform) actinolite. . . . Specular ore of a great variety, in form and color, is frequently met with.

There were shown to us pretty specimens of heavy spar (sulphate of barytes) and talcite, taken also from these mines."[a]

Genth found a mineral associated with quartz and auriferous pyrite in ore from the London and Virginia mine which in composition corresponds to tennantite, the analysis being closely similar to that of a specimen from the Jucud mines, given by Dana.[b] The description of the mineral as given by Genth is quoted below.

"In granular masses; lustre metallic; color between iron-black and lead-gray; streak iron-black; opaque; H. = 4. Very brittle; fracture uneven—subconchoidal.

"B. B. in an open tube disengages sulphurous acid; and gives a sublimate of arsenious acid. On charcoal it emits fumes of an alliaceous odor, and fuses with intumescence to an iron-black, slightly magnetic globule, covering the charcoal with white incrustations. With fluxes it gives the reactions of copper and iron."

A preliminary analysis, made by dissolving the mineral in aqua regia, gave Mr. Wm. J. Taylor the following results:[c]

	Per cent.
Copper	40.64
Silver	0.42
Gold	trace
Zinc	3.39
Iron	4.24
Antimony	5.10
Arsenic	16.99
Sulphur	28.46
Quartz	1.24

The Buckingham Mine.

Location.—The Buckingham mine is situated three-quarters of a mile northwest of Dillwyn, and on the northeast it joins the property of the London and Virginia, both being located on the same vein.

History.—In some of the earliest descriptions of this property it is referred to as the Wiseman mine. The Buckingham Gold Mining Company was organized to operate the property in 1853, and proceeded to develop the mine on a larger scale.[d] The earliest work was limited to open cut mining and the surface openings were carried to a depth of 20 to 40 feet. Later 2 shafts were sunk and levels were driven to some extent along the

[a]Partz, A., Op. cit., p. 379.
[b]Dana, E. S., A System of Mineralogy, 6th ed., New York, 1892, p. 140.
[c]Genth, F. A., Contributions to Mineralogy, Amer. Jour. Sci., 2d ser., 1855, vol. xix, pp. 18-19.
[d]Whitney, J. D., The Metallic Wealth of the United States, Philadelphia, 1854, p. 128.

vein, connecting through with the underground workings of the London and Virginia mine. The deepest shaft is said to have reached 180 feet, but practically all the ore mined came from the upper portions of the vein. It seems probable that two or more mills have been operated on the property, but the principal mill was located near the branch some distance northeast of the mine. The pile of tailings still in existence indicates that much ore was milled here. Austin writing in 1854 states that an average of 20 tons of ore were being crushed daily, yielding 130 dwt. of gold per day, and that during the previous year 1,500 ounces of gold were obtained from the mine. Mining operations ceased several years before the outbreak of the Civil War and have not been resumed since that date. At present the shafts and underground workings are all caved, while the mills were destroyed years ago.

One of the most noticeable features both at the Buckingham and the London and Virginia mines is the absence of large dumps of waste rock. Practically all the material taken from the mines appears to have been put through the mills.

Geology of the ore-body.—As the character of the ore and the geology of the deposit have already been referred to in describing the London and Virginia mine (see pp. 184-190) they will not be repeated here.

The Williams Mine.

Location.—The Williams mine is located at Shepherd's Crossroads about a mile northwest of Dillwyn. It is less than three-quarters of a mile southwest of the principal workings at the Buckingham mine, and lies directly on the same line of strike (see map, p. 185).

Description.—There are several old prospect pits in this vicinity and recently a shaft has been sunk to a depth of perhaps 50 feet. The dump is covered with white quartz-sericite schist impregnated with pyrite and is similar to that at the Buckingham mine already described. Only a very few small fragments of vein quartz are to be seen, indicating the presence of occasional veinlets, mostly less than an inch in thickness. Pieces of this quartz sometimes contain a little pyrite, chiefly along their edges. The recent work is said to have been done with the hope of developing a pyrite mine. Some of the material on the dump carries as high as 80 or 85 per cent. pyrite. A thin section of this high-grade ore (Spec. 344) when examined under the microscope was found to consist of more or less idiomorphic crystals of pyrite, sericite, a few small grains of titanite, and little or no quartz. The pyrite seems to have replaced quartz in the sericite

schist in preference to the other minerals, chiefly sericite, the latter being affected little if at all.

Passing southwest along the strike of the London and Virginia vein, old prospect pits, trenches, and a few shafts are found at short intervals for a distance of 10 or more miles, until the Bondurant mine is reached a short distance southwest of Andersonville. Most of this work was done over 50 years ago, and to-day the dumps are for the most part reduced to soil and overgrown with trees and bushes, so that there is very little to indicate the character of the material that was removed from the openings. The few written records of this early work confirm the data collected in the field, and indicate that the bed of quartzite, which where mineralized forms the greater part of the ore-body at the London and Virginia and Buckingham mines, is practically continuous throughout most of this distance. The quartzite varies somewhat in width and degree of mineralization, but is remarkably uniform in texture and appearance wherever observed. The outcrops are usually stained with iron and the rock more or less porous from the oxidation of pyrite, but in most cases the sulphides could not have been so abundant as in the vicinity of the London and Virginia, and Buckingham mines. While gold is reported to have been found at many of these places, it is improbable that the values anywhere along this southern extension of the vein approach those obtained from the ores at the London and Virginia, and Buckingham, when these mines were being worked. At several of these properties surface washing has been attempted, but with little success, and no underground mining has been carried on.

The Bondurant Mine.

Location.—The Bondurant mine is located about a mile southwest of Andersonville and about 10 miles from Dillwyn.

History.—Placer mining is said to have been conducted on this property as early as 1836, and some of the hillsides as well as the branches were washed for gold. A few years later it was leased from the owner, Mr. Bondurant, by Major Miller, who built a small stamp mill on the branch flowing through the property and worked a vein that outcrops on the hill about 400 feet to the south. A royalty of a tenth of the gold recovered was paid to the owner, and during the period of 10 months in which mining was carried on, he is said to have received $240. Credner visited the property in 1865 and writes that "two parallel veins, 30 feet distant from each other, have been opened by excavations 20 to 25 feet deep, and by two shafts, 35 and 45 feet deep, respectively. One of these veins is two

feet wide and the other four and a half feet. They stand nearly vertical, cross the property for three-quarters of a mile, and carry sandy quartz with much oxide of iron and free gold. The ores were crushed in a stamp mill and amalgamated in arrastras; but tailings only now mark the place where these works stood."[a]

About 1875 a small stamp mill was operated on the property for a short time, with what results is not known. In 1901, a tunnel starting near the creek was driven southeast for a distance of 410 feet, connecting with three shafts having depths of 30, 40, and 71 feet, respectively, and from a point near its extremity a drive was opened for 96 feet southwest along a vein. Mr. Moore, who had charge of the work at the time, states that 5 parallel veins were encountered in the tunnel, the largest being 31 feet thick while the others ranged from 3 to 8 feet, and that another vein was located by a test pit on the opposite side of the creek. He says that assays were obtained running as high as $65 per ton, the veins averaging $4.50 per ton in gold.

Descriptive geology.—The few exposures observed in the vicinity of the Bondurant mine indicate that the country rocks are similar to those at the mines near Dillwyn, which have already been described in detail on pages 184-187. Quartzite, frequently containing magnetite and specular hematite, is the chief rock found on the surface. When the property was visited by the writer in 1911 the greater part of the tunnel had been rendered inaccessible through caving, but the dump afforded much information concerning the character of the rocks.

The so-called "veins" appear to be beds of quartzite, more or less mineralized and cut by occasional veinlets or stringers of massive crystalline quartz, which frequently contain large crystals of muscovite. A specimen (312) of the quartzite cut by small lenses and stringers of vein quartz is shown in fig. 18. The quartzite is white when fresh, fine-grained, even-granular, and slightly schistose, the schistosity being parallel to the bedding. Looking at a piece that has been fractured across the schistosity, the rock appears to consist entirely of quartz with a little fine-grained pyrite, but on a fracture parallel to the schistosity, much white, fine, scaly sericite is visible. Lenticular eyes and stringers of vein quartz occur parallel to the bedding and also cut directly across, as shown in fig. 18. Fine-grained pyrite, much of which is in such small particles as to be almost invisible to the naked eye, is disseminated through the quartzite,

[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, p. 72.

being somewhat more abundant along the principal bedding planes and in close proximity to the veinlets, but the impregnation with sulphides does not appear to be nearly so extensive here as at the London and Virginia, and Buckingham mines.

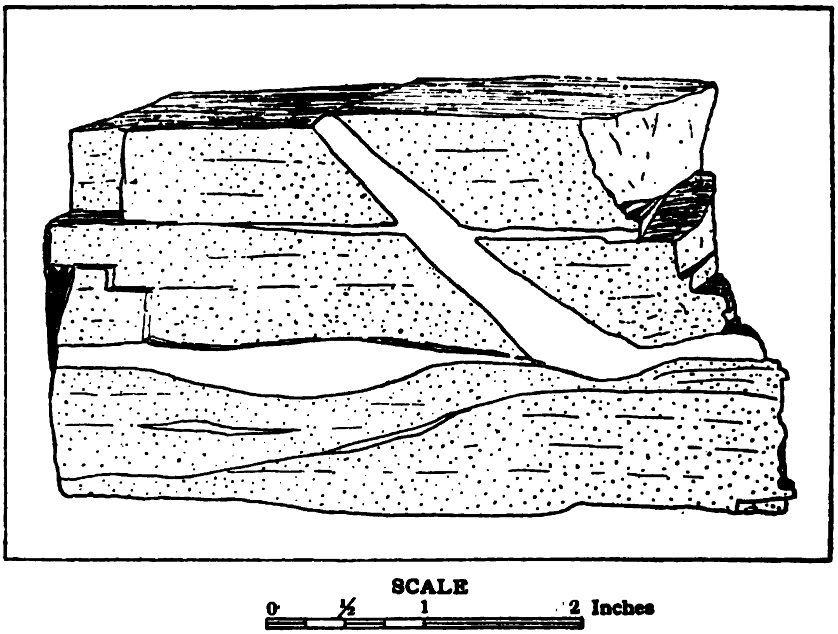

Fig. 18.—Sketch of specimen showing quartz veinlets cutting across bedding and schistosity of quartzite, Bondurant Mine.

The quartzite is interbedded with a fine-grained quartz-sericite schist, containing lenticular eyes of light blue opalescent quartz ranging up to 0.75 cm. in length. The folia of the schist are wrapped around these eyes giving a knotted or bird's-eye maple like structure to the rock. Pieces of quartzite were found on the dump with the schist still adhering, and the contact between the two is not perfectly sharp but shows some gradation. Another piece of schist contained interbedded layers of quartzite that were only a half to an inch in thickness.

Some of the rock (Spec. 366) found on the dump is intermediate in composition between the typical quartz-sericite schist of the district and the quartzite. It is a fine-grained, close-textured, light gray schist, with a faintly greenish tinge due to microscopic flakes of chlorite and sericite. In

thin section under the microscope the minerals present, in the order of relative abundance, are quartz, pyrite in cubical crystals ranging up to about 0.5 mm. in diameter, small flakes of sericite and chlorite, a few grains of magnetite, and occasional inclusions of zircon and titanite.

A little diabase (Spec. 368) was found on the dump. It is a fine-grained, close-textured, dark gray rock in which no olivine could be identified with the aid of a pocket lens.

The Anderson Mine.

Location.—The Anderson mine, located about a quarter of a mile south of Andersonville postoffice, lies just northeast of the Bondurant mine.

Description.—The big bed of quartzite opened on the Bondurant can also be traced across this property by outcrops and old pits scattered along its line of strike. A shaft is said to have been sunk on the property to a depth of 50 feet, connecting with a tunnel 70 yards long, but both had caved before 1865, and to-day there is little trace of their former existence. A little placer washing was done in the branches soon after gold was discovered, but that is the extent of the mining operations conducted on this property.

The Flood Mine.

Location.—The Flood mine lies southwest of the Bondurant and is separated from it by Willis River.

Description.—This property was formerly known as James Anderson's mine, and a little placer washing in the branches is said to have been carried on soon after gold was discovered in the district, but with what success is not known. A shaft and tunnel were opened prior to the Civil War, but they have long since caved, and nothing is now known as to the character of the vein exposed.

The Gilliam Mine.

The Gilliam mine adjoins the Flood mine and is the most southwesterly opening on the bed of quartzite, apparently continuous for so many miles northeast of the property. Whether it stretches yet further to the southwest is not known. According to Credner, who examined the property in 1865, when the "vein" was exposed by 7 cuts and a shaft 20 feet deep, the "vein" is standing vertical and has thinned to a width of only 4 feet. He states that the outcrop consists of brown oxide of iron with only a little quartz, which indicates that the quartzite is probably more heavily impregnated with pyrite than at the Bondurant mine.

The Burnett Mine.

Location.—The Burnett mine is situated on the London and Virginia vein about three-quarters of a mile northeast of the London and Virginia mine and 1¼ miles north of Dillwyn.

History.—This property was formerly known as the Staples mine, and, when visited by Credner in 1865, there was a shaft 54 feet deep exposing "a multitude of lenticular quartz concretions in talcose [quartz-sericite] slate of bluish color which contain oxide of iron and free gold. The bushel, or one hundred pounds of this ore, is worth one dollar."[a] The London and Virginia vein was not opened on this property until 1881, when the Burnett Mining and Milling Co. began development work. A shaft was sunk to a depth of 80 or 90 feet and a short tunnel driven from the southwest along the vein to connect with the shaft. There was another shaft a few yards northeast and a number of pits, all of which are now caved. The mine was worked during 1881, 1882, and a part of 1883, but has since been idle.

A mill was located 300 to 400 yards west of the mine on the west side of a large branch. It consisted of 3 batteries of 4 stamps each. The mortar boxes were of cast-iron, while the stamps had square wooden stems with cast-iron shoes. The mill burned some years ago, but the charred stumps of the stems can still be seen standing in the batteries. There is quite a large tailings pile below the mill, but it is said that most of the ore milled was hauled from the London and Virginia mine.

Descriptive geology.—The country rock, as indicated by the dump and by rock in place in the shaft, is a white, lustrous quartz-sericite schist impregnated with fine-grained pyrite, similar in every way to the rock occurring on the northwest side of the vein at the Buckingham mine. The "vein," exposed in the shaft, is a bed of quartzite 3 to 4 feet thick, having an approximate strike of N. 45° E. and a dip that is vertical or steeply inclined toward the southeast. The quartzite is very schistose and contains considerable sericite. In most places near the surface it is colored dark brown by the oxidation of pyrite, which has left small cavities in the rock. This ore is similar to that at the London and Virginia and the vein has been traced from one mine to the other by means of surface cuts, outcrops, and float.

[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, p. 72.

The Hobson Tract.

The Hobson tract, formerly known as the Morton mine, lies between the Burnett mine and the London and Virginia. According to Credner a 40-foot shaft was sunk on the London and Virginia vein which here attains a width of 10 to 15 feet and exhibits the characteristic appearance of the quartzite where the pyrite has been thoroughly oxidized. The vein has never been worked to any extent on this property.

The Morton Mine.

Location.—The Morton mine is located half a mile west of Johnson, a station on the Buckingham Branch of the Chesapeake and Ohio Railway, and is about 7 miles northeast of the London and Virginia mine.

History.—This property was formerly known as the Hobson mine, and according to Pollard it was the first mine opened in the county. Surface washing was carried on in the early days. When the property was visited by Credner in 1865 three parallel veins had been opened to a depth of 25 or 30 feet. He states that they are from 3 to 10 and in some places even 20 feet wide, and consist of granular massive quartz carrying oxide of iron and free gold. One of these veins is said to be the continuation of the London and Virginia vein.[a] In 1906, two shafts, the deepest probably not more than 30 feet, were sunk on the property, but there is nothing on the dumps to indicate that either one struck a vein. When the writer visited the property in 1911 all openings had caved except the last mentioned shafts. There is an old dam on the small branch west of the shafts, and on the opposite side the ruins of a building, said to have been used in washing gold. A little water-worn gravel was found around the building.

Geology.—The mine is situated in an area of quartzites and schists, lying just west of the Arvonia slate belt and in line of strike with the London and Virginia mine which is 7 miles southwest. The two shafts sunk in 1906 were put down in a quartz porphyry, fresh specimens of which were exposed on the dump.

The rock (Spec. 360) is light gray to nearly white, slightly schistose, and is composed for the most part of feldspar and quartz. Occasional eyes of light blue to colorless, opalescent quartz, ranging up to 0.75 cm. in diameter, are distributed through the rock. A few grains of ilmenite and pyrite, and along cleavage planes a little sericite and chlorite make up the remaining constituents visible to the naked eye. In thin section

[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, p. 58.

under the microscope, the large quartz eyes are seen to be full of small zircon crystals, exceedingly minute rutile needles, and gas and liquid inclusions. The potash feldspars (orthoclase and microcline) are dominant over the soda-lime feldspar (albite-oligoclase or oligoclase) and orthoclase is more abundant than microcline. There is also much microperthite present in the slide. The minerals show no granulation and little if any optical distortion, but the feldspars show some alteration to sericite, and to calcite, while the ilmenite is partly altered to leucoxene.

Between the Morton and the London and Virginia mine, and along the same general strike, a number of properties have been prospected by means of pits and surface cuts, but no regular mining, aside from placer washing, has been conducted on any of them.

A property, formerly known as the Rough and Ready mine, adjoins the Morton mine on the southwest. At some time before the outbreak of the Civil War a shaft was sunk on a quartz vein carrying pyrite, and, in 1879, a pit opened on the property is said to have exposed a vein 6 feet in width which showed gold on panning.

On the Duncan tract, about 1½ miles west of Alpha, the gravel deposits along the branches were formerly worked for gold and a vein on the property was prospected a little but never worked.

Lying between the London and Virginia and the Duncan properties is a tract of land, which at different times has been known as Le Seur's or Apperson's mine, and on it a vein is said to have been explored and some ore raised before the war. Later prospecting was renewed, and in 1882 Campbell writes that 3 veins were exposed. The first, measuring 10 to 15 feet in width, consisted of a porous siliceous mass containing disseminated particles of gold. The second vein, about half a mile east of the first, was of whiter quartz but had not been well exposed. The third vein, which was still farther to the east, consisted of gold-bearing quartz disseminated in hard schistose rock like that at the Morrow mine.[a]

The Morrow Mine.

Location.—The Morrow mine is located about 3½ miles southwest of Dillwyn and 2 miles east of Enonville.

History.—It was one of the first properties in Virginia on which underground mining was attempted and has had a long and varied history. When Prof. W. B. Rogers wrote his "Report of the Geological Recon-

[a]Campbell, J. L., The Virginia Gold Belt near the Richmond and Alleghany R. R., The Virginias, 1882, vol. iii, p. 120.

noissance of the State of Virginia, 1835," Booker's mine, as it was then called, was already in active process of development. In its early history the property consisted of 2 separate mines on the same vein within 100 yards of each other, which were worked by W. M. Moseley and Co., and the Garnett Mining Co., respectively; but in 1852 they were consolidated under one management and incorporated under an act of the Virginia Legislature. For several years after this the property was controlled by an English company. In the early writings on geology and mining, the workings were usually referred to as the Garnett and Moseley mines, or the Booker mine, but since about 1880, when it was worked for a few years by the Morrow Mining Co., it has been known as the Morrow mine.

Several mills have been built on the property and much money has been wasted through the installation of expensive machinery, which after little or no use was pulled out to make room for later inventions. While the Garnett and Moseley mines were being worked separately there were two small mills in operation. In 1854, soon after the English company had bought the mine, Mr. Partz[a] states that a new mill with 72 stamps was in operation, replacing the 24 stamps that had previously been employed, and that the amalgamation was performed on two sets of shaking tables. When Credner visited the district in 1865 the mines were shut down, but he describes two mills he found on the property; one containing 4 shaking tables, nearly new, and a very large ball-crusher which had not been used; the other with 12 batteries of 3 stamps each, 72 shaking tables, arranged in 2 systems, and Chilian mills.[b] In later years, a Howland mill, consisting of a flat circular disk revolving in an iron shell, was used to pulverize the ore, and the sulphides were concentrated on 2 vanners. An attempt was made in 1893-4 to treat the sulphides by the Mears chlorination process, but it is said to have failed because of mechanical defects in the process used, though a satisfactory extraction of the gold was obtained.[c] In 1911 there was no mill on the property.

Production.—Because of lack of records it is not possible to state the total amount of gold produced by this property. A prospectus of the Garnet Gold Mining Co., printed in 1852, gives the production of both mines for the previous year as follows:

United States Mint receipts for gold	$25,007.53
Gold on hand and ore reserved as specimens	1,500.00
Total	$26,507.53

[a]Partz, A., Examinations and Explorations on the Gold-Bearing Belts of the Atlantic States, Mng. Mag., 1854, vol. ii, p. 378.

[b]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1868, vol. vi, p. 393.

[c]Froehling and Robertson, A Hand-Book on the Minerals and Mineral Resources of Virginia, 1904, p. 48.

Mr. W. J. Henwood gives the amount of gold derived from both mines for the years 1850-2 inclusive.[a]

Annual production of gold in pounds Troy.

Year	Garnet mine.	Moseley mine.
1850	.....	97.92
1851	36.75	71.74
1852 (8 months)	20.17	31.19

Over $60,000 is said to have been recovered from the placer washings near the veins.

Underground development.—Before underground work was resorted to, most of the upper portion of the Booker vein was removed by open-cut surface mining down to a depth of 30 feet, and for a distance of over 400 yards along the outcrop. By 1853, it is said that 5 shafts used for hoisting, ventilation, and pumping had been sunk to an average depth of 100 feet, and connected by drives 350 feet in length. The vein had been proved for over half a mile by 4 or 5 shafts 30 to 50 feet deep, and by as many as 50 surface cuts.[b] Later development work extended the underground workings, and a good deal of stoping was done, but none of the shafts seem to have been carried below 115 feet. When the property was visited in the summer of 1911, the openings had partly caved and none of them was accessible.

Descriptive geology.—The Morrow mine is situated in an area of intensely metamorphosed schists and gneisses, which, for the most part, are probably derived from sedimentary rocks. At Tongue Quarter Creek about a mile southwest of the mine there is a large area of fine-grained, dark green, hornblende schists, and 2 miles southwest of the property are the bold outcrops of cyanite schist and quartzite that form Willis Mountain.

In the immediate vicinity of the mine there are few rock exposures, but the old shaft dumps furnish much information concerning the character of the country rock enclosing the ore deposits. These rocks are all schistose and usually show more or less banding; they range from light to dark gray and green in color, are usually garnetiferous, and frequently contain an abundance of calcium-iron carbonate, probably a variety of ferrocalcite. The latter mineral is finely crystalline and light brown in

[a]Henwood, W. J., Observations on Metalliferous Deposits, Trans. Royal Geol. Soc. of Cornwall, 1871, vol. viii, p. 382.

[b]The Garnet and Moseley Mines, Virginia (Reprinted from a paper by "The Editor," in the Richmond *Enquirer*), Mining Mag., 1853, vol. i, pp. 164-167.

color when fresh, turning to dark brown on weathering; it effervesces very slowly in cold dilute hydrochloric acid, and on heating before the blowpipe becomes only slightly magnetic. Wet tests give heavy precipitates of calcium and iron, but little or no magnesium.

A thin section was made from a light gray, gneissic rock in which the carbonate was particularly plentiful. Megascopically the rock (Spec. 378) shows imperfect banding of the light- and dark-colored minerals; the lighter bands being largely composed of carbonate and quartz, while in the dark ones biotite is a prominent constituent. White mica, pink garnets, and a few small grains of magnetite and pyrite may also be recognized. Under the microscope, carbonate is dominant in the thin section, with quartz, sericite, biotite, soda-lime feldspar (andesine ?), and garnet following in the order named. Some of the quartz shows much optical distortion, but large clear grains of secondary quartz are also present. The feldspars are fresh and clear, and usually show multiple twinning after the albite law. The garnets show no suggestion of crystal form, and are simply granular aggregates, intermixed with the other minerals, principally carbonate.

There is much light gray schist (Spec. 379) on the dumps, in which the principal constituents distinguishable without the aid of the microscope are fine-grained quartz, sericite, scattered flakes of biotite, averaging 1 mm. in diameter, and occasional eyes of opalescent quartz 5 or 6 mm. in diameter.

Another rock type (Spec. 376) occurring on the dumps, is a dark green and reddish-brown gneiss in which most of the minerals (especially mica and garnet) are very largely concentrated in narrow bands or lenses. Megascopically, the following minerals can be distinguished: Biotite, in black flakes 0.5 to 1.5 mm. in diameter, which occur partly in narrow bands, the cleavage of the mica being at varying angles with the schistosity of the rock; garnet, in irregular lenticular masses 1 cm. or more in thickness; fine flakes of sericite and light green chlorite; quartz; much fine-grained magnetite; and occasional feldspars, 1 to 1.5 mm. in diameter.

In thin sections under the microscope, much feldspar can be distinguished, partly a soda-lime feldspar with albite twinning, and partly a clear feldspar with low index of refraction and no twinning (albite or orthoclase). Much of the feldspar and quartz show optical distortion, and in places zonal extinction can be observed. In addition to the minerals already mentioned, much calcite was noted, and occasional fragments of zircon and titanite. Gas- and liquid-filled cavities occur in some of the quartz.

Dark green hornblende is present in part of the schists, and some pieces are heavily loaded with the sulphides, pyrite and pyrrhotite. Some of the pieces of schist and gneiss contain lenses or stringers of quartz and carbonate, usually with a little white mica; and there is a great deal of rock (Spec. 373) on one of the dumps, consisting of dark-colored, fine-grained schists, cut by numerous branching veinlets of quartz and carbonate, with some muscovite and light green chlorite. These veinlets range up to several inches in thickness, and often make up as much as 50 per cent. of the rock mass. This material is very similar to some of the "vein" stuff described by a number of geologists who have examined the underground workings. Thus, Prof. Campbell states that, "the 'vein,' as it is called, in which work was going on [at the time of his visit in 1881 or 1882], is at least 30 feet wide, and is composed of a schistose rock with injected quartz, forming in some places secondary veins and thin sheets, and at other points, apparently dispersed, with its accompanying auriferous pyrites, in the slaty beds of hard rock that make up the main mass of what is taken from the mine."[a]

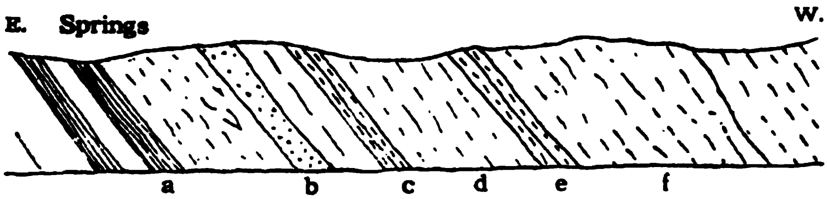

Fig. 19.—Section across the district worked for gold in the Morrow Mine. (After Ansted, Scenery, Science and Art, p. 289.) *a*, rotten schists with pipe clay; *b*, steatite; *c*, principal auriferous band called east vein; *d*, hornblendic rock; *e*, upper auriferous band (west vein); *f*, overlying beds.

Prof. Ansted describes the "belt" of rocks in which the ore bodies occur and gives a geological section showing the structural relations of the rocks in their immediate vicinity. (See fig. 19.) His description is as follows:

"The actual breadth of this belt I had no means of exactly ascertaining, but it certainly exceeds 200 yards, and is probably much greater. It is, however, subdivided, including distinct bands of mixed quartz threads and rotten red and yellow or greenish schists (*a*). On these repose bands of talcose or chloritic schist, which pass into an imperfect steatite (*b*), occasionally used as a firestone to line furnaces. All these are on the east or lower side of the series. In the middle, between the two well-marked auriferous bands which next succeed, is a certain thickness of hornblendic greenstone (*d*) hard, and tolerably compact. The eastern auriferous band has been extensively worked at the surface."[b]

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[a]Campbell, J. L., The Virginia Gold Belt near the Richmond and Alleghany R. R., The Virginias, 1882, vol. iii, pp. 120-121; Geology and Mineral Resources of the James River Valley, New York, 1882, pp. 99-106.

[b]Ansted, D. T., Scenery, Science and Art, London, 1854, Chap. 3, The Alleghanies and the Gold District of Eastern Virginia, pp. 289-290.

Henwood states that the rocks exposed in the mine contain "mica, talc [probably sericite], and chlorite in large but ever-varying proportions," so that one or the other may dominate in laminæ only a few inches apart, or even in different portions of the same rock layer.[a]

Besides the "principal bed," Henwood mentions four other "auriferous beds," occurring in and immediately northwest of the mines, which "maintain tolerable parallelism; except where they are affected by unequal flexures of the adjoining rock; to the schistose structure of which they strictly conform." They vary from 4 to 18 feet in maximum width, but average much less, and "within short distances some of them divide, dwindle, and die away; occasionally, however, they reappear and again enlarge."[b]

The slates beneath the "principal bed" dip northwest at an angle of 40° to 60°, but those above preserve the same inclination to a depth of 60 feet only, and thence downward dip 20° to 30°. As the hanging-wall or northwestern side recedes from the foot-wall, and the "auriferous bed" between them becomes broader, it encloses lengthwise a wedge-shaped mass of slate, which widening downward partakes in some measure of the mineral character of the surrounding "vein-stone," while in structure it coincides with the neighboring rocks.[c]

According to Prof. Ansted, "the enclosing rock, which within 20 feet of the surface is hardly to be distinguished from the vein, gradually changes below this point, and within a depth of 10 or 15 feet becomes a hard, compact talcose [probably quartz-sericite] schist, often containing fine garnets, and not infrequently iron pyrites. In this schist, at a small depth, are a multitude of quartz threads, and farther down these threads come together, forming a distinct quartz band, often enclosing portions of the schist. The gold disseminated indifferently near the surface, amongst the quartz, rotten schists and enclosing walls, gradually collects together into threads, usually ranging with the schistose portions within the quartz band. The walls are very distinctly marked, and easily separated, and are found to be no longer auriferous, while the quartz, of which the thickness amounts to 10 feet at a depth of about 100 feet from the surface, seems to increase continually in value."[d]

The appearance of the vein is shown in the generalized sketch (fig. 20), which is drawn from pieces of rock found on the dump, and is in accordance with the descriptions of several observers, who have examined the underground workings.

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[a]Henwood, W. J., Observations on Metalliferous Deposits, Trans. Royal Geol. Soc. of Cornwall, 1871, vol. viii, p. 379.

[b]Ibid., p. 380.

[c]Ibid., pp. 380-381.

[d]Ansted, D. T., Op. cit., p. 290.

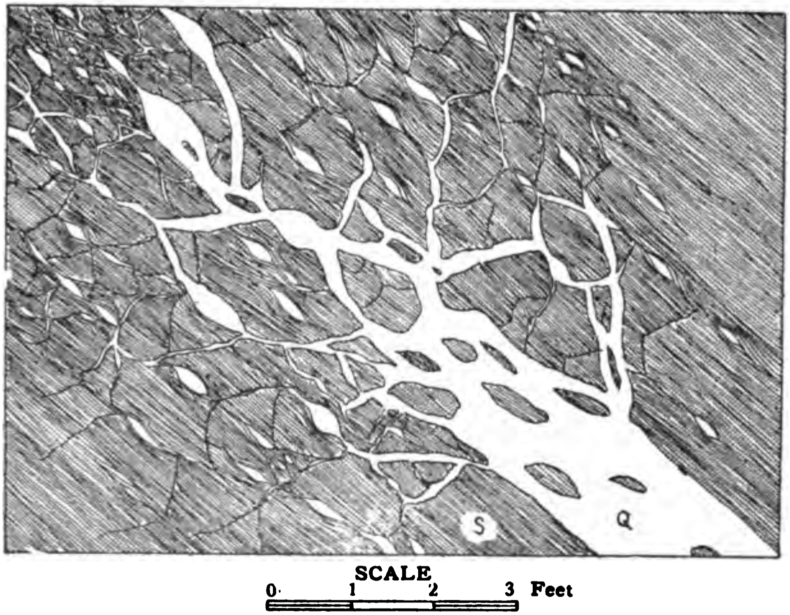

Fig. 20.—Sketch showing reticulated veinlets with inclusions of wall rock at the Morrow Mine. *Q*, quartz; *S*, schist.

Description of ores.—Quartz and schist, varying in relative proportions, always make up the greater part of the ore-body, but Henwood also mentions the presence of small quantities of feldspar scattered throughout, and in the deeper portions calcareous spar, pyrite, and crystals of common garnet. He states that veinlets of quartz, feldspar, and calcareous spar cut the metalliferous beds at intervals irrespective of their slightly foliated structure, which is generally parallel to the cleavage of the adjoining strata. Near the surface all parts of the rock-mass contain particles and grains of gold but at greater depths, in the "principal bed" flakes, granules, nuggets, and threads here and there intertwine the quartz with groups of golden filigree. It is stated that tellurium often accompanies the gold but is never abundant.[a] According to Campbell the gold is said to carry a considerable percentage of silver.[b]

[a]Henwood, W. J., Op. cit., p. 382.
[b]Campbell, Op. cit.

Henwood believes that there is a decrease in values with depth, and after calling attention to the gradual decrease in production for the years 1850-52 (see p. 200), during which time approximately the same number of men were employed in extracting the ore, states that, "these results show the proportions of gold to have been larger in the shallower and narrower, than in the deeper, wider, and flatter parts of the principal bed."[a]

Selected samples are said to have carried 3 oz. 16 dwts. in gold, but ore from a depth of 90 feet in the Garnett mine yielded an average of 10.1 dwt., and from the Moseley mine an average of 8.1 dwt.[b]

Credner says that the gold-bearing beds are cut off by domes and ridges of diorite; but the mines were closed at the time of his visit in 1865, and he does not give his authority for this statement.[c]

Placers.—During the early history of the property the placer deposits were much worked, and over $60,000 is said to have been recovered from the gravels near the veins. Henwood quotes Major Miller as writing that "a nugget of nearly 9 pounds, besides many masses of a few ounces each were mixed with grains of gold in the bed of a rivulet immediately south of the Garnett and Moseley mines."[d]

The Seay Mine.

The Seay property adjoins the Morrow mine on the west, lying between it and Enonville, and belongs to the same company.

The placer gravels were washed for gold and several quartz veins containing pyrite and gold were opened by cuts and small shafts. There was a mill on the property before the Civil War, but little mining seems to have been done. After the war a shaft is said to have been sunk to a depth of 150 feet but nothing further was done.

The Greeley Mine.

Location.—The Greeley mine, lying on the headwaters of Hatcher Creek. is situated about 1½ miles southeast of Alpha, a station on the Buckingham Branch of the Chesapeake and Ohio Railway, and a mile southwest of Gravel Hill.

History.—The placer deposits at the Greeley mine, formerly known as Ayres' mine, were worked during the early days of gold mining in this

[a]Henwood, W. J., Op. cit., pp. 282-283.
[b]Ibid., pp. 282-283.
[c]Credner, H., Op. cit.
[d]Henwood, W. J., Op. cit., p. 384.

county, and it is reported the branch gravels yielded much gold. Prospecting has been carried on at various times in the endeavor to locate the vein from which the placer gravels derived their gold, and many pits, trenches, and shafts have been opened with this object in view, but to-day they are all caved. There are several large trenches, leading toward the top of a hill, the largest being 30 to 40 feet wide, about the same depth, and several hundred feet long in a northeast-southwest direction. While these trenches look rather large for the purpose, they are said to have been cut while prospecting for the vein. When Credner visited the mine in 1865 a mill was being started, but it was probably never finished, and except for the placer washing no mining has been done on the property.

Veins and country rock.—Several veins were located by open pits and one of them is reported to have carried free gold, but the vein quartz exposed when the property was visited by the writer showed little evidence of mineralization.

The lack of outcrops on the property and in its immediate vicinity makes it difficult to draw conclusions in regard to the country rock. A few pieces of quartz-sericite schist are found on the surface, and at a distance of a mile or more northeast and southwest along the strike of the formations, schists and quartzites are exposed which apparently belong to the same series as the rocks in the bluffs near New Canton.

One of the shafts is sunk in a gray granitic rock (quartz monzonite) which is distinctly schistose. The rock (Spec. 348) is fine-grained and even-granular, and a microscopic examination showed it to be composed of the following minerals, the order given being that of relative abundance: Quartz, biotite, feldspar, hornblende, calcite, garnet, chlorite, magnetite, zircon, and tourmaline. The feldspar corresponds to andesine in composition and shows albite twinning, and orthoclase if present is rare. The biotite is dark brown in color with strong absorption. Hornblende occurs in light to dark green crystals, with ragged outline, and low interference colors. Calcite which is fairly abundant frequently shows multiple twinning. The garnets which are light pink in color show ragged outlines and contain numerous inclusions of the other minerals. Both biotite and hornblende show alteration to chlorite which is dark green in color. Magnetite occurs in clusters of small grains and zircon is quite plentiful as inclusions. A prism of tourmaline is present in the slide. It is strongly pleochroic changing from reddish-brown to dark green.

Much of the rock is cut by veinlets ranging up to 2 inches or more in width, but mostly less than an inch. In places calcite forms one side

and quartz the other of a veinlet, but usually they are intermixed, quartz occurring in calcite and calcite in quartz. Often the veinlets are much contorted, and again they branch and intersect. The contact between the rock and the veinlets is not always perfectly sharp but shows a slight gradation. Occasionally large crystals of muscovite 4 or 5 cm. in diameter are intercrystallized with the quartz and calcite. Where plentiful the flakes of muscovite meet one another at all angles, and the interstitial space is filled with quartz and calcite. Light-colored pyrite is present in the vicinity of some of the veinlets, occurring in cubes 2 to 3 mm. in diameter.

The Lightfoot Mine.

Location.—The Lightfoot mine is situated on the southeast side of Slate River, 2 miles north of Arvonia.

History.—While this property is now better known as a copper mine (see p. 241) it was first worked for gold. It is said that the discovery of the mine was due to Geo. Fisher, who worked the property for several years under lease. After the expiration of his lease it was worked successively by three different companies, who leased it from the proprietor, Mr. Lightfoot. The first of these companies is reported to have made $300 to $400 per day stamp-milling for gold. The second company confined its work to surface washing, and the last company developed the copper deposits, shipping 100 tons of $80-ore to Baltimore, before the mine was closed by the outbreak of the war in 1861. Since that time no work has been done on the gold veins and at present there is little trace of these former operations. In working the placer deposits, gold nuggets worth $20 to $30 are said to have been found.

Gold veins.—The country rock in this vicinity is a greenstone schist, which is described in detail on pages 49-51. Credner states that at the time of his visit, in 1865, two gold veins were exposed by pits and shafts which had partly caved. One of these was 4 feet wide and carried iron sulphide and free gold.

Gold has also been found on the Ford property (see p. 243).

CHAPTER VI.

GENETIC RELATIONS OF THE GOLD DEPOSITS.

INTRODUCTION.

The genesis of ore deposits has frequently been regarded as a question of scientific interest only, but with increasing knowledge of the subject it is beginning to be of great practical value from an economic standpoint. The unraveling of the structural relations of ore-bodies, particularly in regions of extensive faulting, has long been recognized as invaluable to the miner, and there is a growing appreciation of the importance of ore genesis. A thorough understanding of the mode of formation and of the subsequent alterations which may have enriched or impoverished an ore deposit, is the only logical basis on which it is possible to predict the continuity and character of the ore-body in depth, or to indicate the probable location of other deposits that may not be exposed.

Previous Theories.

The first geologists to study the gold-bearing veins in this district advanced two antagonistic theories to explain the formation and occurrence of the ore deposits, and both of these theories have had strong supporters. According to one theory, the veins were forcibly injected by igneous agencies into older rocks; and since the lines of least resistance were usually along planes of bedding and schistosity, the veins, as a rule, conformed to the structure of the enclosing formations, although in places they split up and cut across. This explanation was advanced and supported chiefly by Rogers (see page 10). The opposing theory was based on the assumption that the ore-bodies were layers or beds deposited contemporaneously with the enclosing rocks. This explanation as applied to the origin of Virgina gold veins seems to have been advocated first by Clemson and Taylor[a], and was later supported by Silliman, Ansted, Credner, and others. Most of these geologists seem to have ignored the fact that some of the veins in places cut across the bedding of the country rock, but others, following Ansted, attributed this anomaly to changes brought about by "chemical agency" or by a "process of segregation" (see p. 11).

[a]Clemson, T. G., and Taylor, R. C., The Gold Region of Virginia, Trans. Geol. Soc. Pa., 1835, vol. i, p. 309.

The facts established by the present report in many ways support the views advocated by Rogers but there are certain important exceptions which will be noted later. After examining, at the Tellurium mine, the bed of quartzite known as the "Big Sandstone" vein (see pp. 157-164), it is easy to understand how the early geologists came to regard the veins as sedimentary in origin, for this quartzite is at a glance closely similar to the auriferous quartz veinlets which it encloses.

Types of Deposits.

The primary gold deposits in this district may be divided into two principal types: (1) Veins accompanied by little or no replacement or impregnation of the wall rock, and (2) ore-deposits which have been formed chiefly through replacement—but there is apparently every gradation between the two extremes. Ores belonging to the first type consist essentially of quartz, with more or less feldspar and variable quantities of gold. The sulphides, chiefly pyrite, are always present in small quantities, but seldom average more than 1 per cent. In the ores belonging to the second type, pyrite is the most important constituent and chalcopyrite it fairly common. The veins belonging to the Tellurium system, particularly the "Middle" vein, may be mentioned as typical examples of the first class. The veins at the Young American mine are also of this type, for though there has been in places considerable mineralization of the wall rock, it is nowhere extensive, and is usually in the nature of silicification of the country rock.

The typical replacement deposits were found only in the southern portion of the area in Buckingham County. The London and Virginia vein is an example of the latter class, and the New Canton ore-body probably represents an extreme variety of this type. Under a strictly logical treatment of the subject the genesis of the New Canton ores should probably be considered in this chapter, but because of their localization near an igneous contact, their insignificant gold content, and the fact that they have been worked chiefly for copper, it has been thought best to discuss them elsewhere (see pp. 257-259).

MINERAL COMPOSITION OF THE VEINS.

The consideration of minerals associated with gold is important, not only because of their possible value as indicators of the presence of the precious metal, but also for the reason that such minerals furnish the most reliable evidence bearing on the genesis of the ore-deposits. A table,

summarizing the minerals which have been found in the gold-bearing veins of this district, is given below, together with the names of mines where they have been identified, and the authority for each instance cited. Both the minerals and the mines are listed in alphabetical order. The details in regard to any particular occurrence may be found under the description of the mine in chapter V. The table is limited to minerals found within the quartz veins, and no attempt has been made to list those occurring in the replacement deposits as that would necessarily include all minerals present in the wall rock. Common secondary minerals, undoubtedly derived from one of the primary minerals listed, are also omitted.

List of minerals in the gold veins of the James River basin area, Virginia.

Name.	Mine.	Authority.	Remarks.
GANGUE MINERALS:			
Actinolite	London & Virginia	Partz, 1854	Probably in wall rock.
Barite	Do.	Do.	Questionable.
Biotite	Bowles	This report	Probably derived from inclusions of wall rock.
Do.	Waller	Do.	Along the walls of the vein.
Do.	Young American	Do.	Probably derived from inclusions of wall rock.
Calcite	Morrow	Henwood, 1871	Probably ferrocalcite.
Do.	Waller	This report	Found on the dump.
Do.	Young American	Do.	In vein near wall and along the contact.
Chlorite	Bowles	Do.	Probably from altered inclusions of wall rock
Do.	Hughes	Do.	Do.
Do.	Morrow	Do.	Do.
Do.	Scotia	Do.	Do.
Do.	Tellurium	Do.	Do.
Do.	Waller	Do.	Do.
Do.	Young American	Do.	Do.
Cyanite	Young American	Do.	Do.
Feldspar	Benton	Do.	Kaolinized feldspar in ore on dump.
Do.	Bertha and Edith	Do.	Do.
Do.	Buckingham	Do.	Plagioclase feldspar in vein quartz on dump.
Do.	London & Virginia	Do.	Do.
Do.	Morrow	Henwood, 1871	With quartz and calcite as veinlets.
Do.	Moss	This report	Kaolinized feldspar in ore on dump.
Do.	Scotia	Do.	Oligoclase-andesine.
Do.	Tellurium	Do.	Do.
Do.	Waller	Do.	Albite-oligoclase to oligoclase.
Do.	Young American	Do.	Dominantly andesine or oligoclase-andesine.
Garnet	Bowles	Do.	Probably due to inclusion of foot-wall material.
Do.	Morrow	Henwood, 1871	Do.
Hornblende	Do.	This report	Do.
Do.	Scotia	Do.	Do.
Do.	Waller	Do.	Found on old dump.
Muscovite (including sericite)	Benton	Do.	Probably chiefly secondary from feldspars.
Do.	Bertha and Edith	Do.	Do.
Do.	Bondurant	Do.	Do.
Do.	Bowles	Do.	Do.
Do.	Buckingham	Do.	Do.
Do.	London & Virginia	Do.	Do.
Do.	Morrow	Do.	Do.
Do.	Moss	Do.	Do.
Do.	Scotia	Do.	Do.
Do.	Tellurium	Do.	Do.
Do.	Waller	Do.	Do.
Do.	Young American	Do.	Do.

List of minerals in the gold veins of the James River basin area, Virginia—(Continued).

Name.	Mine.	Authority.	Remarks.
GANGUE MINERALS: (*Continued*)			
Quartz	All the mines	....	....
Selenite	Buckingham or London & Virginia	Henwood, 1871	Questionable.
Talcite	Buckingham or London & Virginia	Partz, 1854	Do.
Tourmaline	Bowles	This report	Gold Hill vein.
Do.	Moss	Do.	In vein quartz, associated with pyrite.
Do.	Young American	Do.	In vein quartz, associated with gold and cyanite.
ORE MINERALS:			
Chalcocite	Buckingham	Henwood, 1871	Description indicates mineral is secondary.
Do.	London & Virginia		
Chalcopyrite	Buckingham	Partz, 1854; Ansted, 1854; Henwood, 1871	
Do.	London & Virginia		
Do.	Morrow	Partz, 1854	Mentions presence of copper without stating the mineral.
Do.	Snead	Credner, 1869	
Do.	Young American	This report	
Galena	Buckingham London & Virginia	Credner, 1869; Henwood, 1871	
Do.	Snead	Credner, 1869	
Gold	All the mines	....	
Ilmenite	Scotia	This report	Rare.
Do.	Young American	Do.	Rare.
Leucoxene	Do.	Do.	Rare.
Magnetite	Bertha and Edith	Do.	Associated with pyrite.
Do.	Bowles	Do.	"Back Field" vein.
Do.	Young American	Do.	Associated with pyrite.
Marcasite (?)	Young American	Do.	In vug-like opening, probably left by pyrite.
Pyrite	All the mines	....	
Pyromorphite	Buckingham	Henwood, 1871	
Do.	London & Virginia		
Do.	Snead	Credner, 1869	
Pyrrhotite	Waller	This report	Found on old dump.
Sphalerite	Snead	Credner, 1869	
Do.	Tellurium	This report	Rare.
Do.	Young American	Do.	Rare.
Tellurium (?)	Tellurium	Credner, 1869	Probably tetradymite.
Do.	Morrow	Henwood, 1871	Do.
Tennantite	London & Virginia	Genth, 1855	Given as tetrahedrite by Becker.
Tetradymite	Tellurium	Fisher, 1849; Genth, 1855	Rare.
Do.	Young American	This report	Rare.

Description of the Gangue Minerals.

Quartz is always the most abundant gangue mineral. It varies from milky white and translucent to clear and glassy. It is coarsely crystalline, in places approaching saccharoidal in texture, and is apparently the same wherever it occurs in well-defined veins, lenses, or as a replacement mineral. Crystal faces are rare except along joint planes and in cavities left by the removal of pyrite, where they are probably due to the enlargement of primary individuals by deposition of a little secondary silica. Examined microscopically, the quartz frequently shows some optical distortion but little or no granulation or other evidence of crushing. The individual grains have irregular interlocking boundaries and average from 1 to 3 mm. in diameter. Gas- and fluid-filled cavities are common, sometimes occurring in irregular branching and interlaced forms, but more often in smaller spherical and elliptical shapes, which are usually grouped in rows or planes that occasionally extend unbroken from one crystal individual to another.

Feldspar is the second gangue mineral in relative abundance, having been identified in all veins that were well exposed, and in places constitutes as much as 10 per cent. of the vein material. It occurs in angular crystals, ranging up to 1 cm. or more in diameter, scattered through the quartz, but is usually much more plentiful near the walls of the veins. In some of the smaller veins, and in places where quartz lenses narrow and pinch out (see fig. 14), feldspar is sometimes for a limited distance practically the only constituent. When fresh, the feldspars are white to light yellow or light pink, and are often difficult to distinguish from the quartz without careful examination. In the upper portion of the veins above water level the feldspars seem to be entirely kaolinized, but wherever specimens could be obtained, sufficiently unaltered for identification by optical methods, they proved to be soda-lime plagioclase, ranging from albite-oligoclase to andesine. No orthoclase or albite could be distinguished in any of the veins. In thin sections under the microscope the feldspars commonly show albite twinning but many of them are entirely unstriated. There is no evidence of optical distortion, granulation, or other pressure effects. In places a little sericite is present as an alteration product of feldspar, occurring in clusters of curved and radiating scales, but kaolin is the chief secondary mineral. The feldspars are probably of earlier crystallization than most of the quartz.

White potash mica is one of the important gangue minerals, apparently occurring in all of the veins. Some of it is in large flakes such as are usually called muscovite, while much is in the form of shreds and scales,

evidently secondary in origin, and commonly designated as sericite. Sericite is a prominent constituent of the wall rocks and is especially plentiful in some replacement deposits.

Biotite and chlorite are frequently present in the veins, but their occurrence is such as to suggest that they were chiefly if not entirely formed from inclusions of country rock through alteration by vein-forming solutions. The chlorite is partly secondary after biotite and partly derived from hornblende; it is doubtful if any of it is an original constituent of the veins. Garnet and hornblende rarely occur within the quartz veins and where identified were found close to the walls. These four minerals are occasionally prominent in the wall rock, and their occurrence and distribution indicate that their formation was chiefly due to metamorphic agencies accompanying the formation of the veins.

Black prisms of tourmaline, usually arranged in radiating groups, occur in some of the gold-bearing veins, and one specimen was found showing visible gold resting on tourmaline (see p. 131). Tourmaline was seen in association with auriferous pyrite, and was also identified in a piece of vein quartz containing cyanite. Tourmaline was not noted in any of the veins containing much feldspar, and seems to be most plentiful in certain bold outcrops of white quartz, which show little evidence of mineralization and contain only traces of gold.

Cyanite was identified in only one of the gold-bearing veins (see pp. 128-129), but was found in several quartz veins not known to contain gold. It was found in metamorphosed wall rock close to veins under conditions that indicate its origin was due to vein action.

Description of the Ore Minerals.

Gold occurs chiefly in quartz and mechanically enclosed in pyrite, always so far as known in the native state. In the oxidized ores it is frequently found in cavities associated with limonite. It was seen in small scales, grains, and irregular wire-like masses ranging up to 3 mm. in length, and much larger particles have been reported from some veins. No evidence of crystal form could be distinguished. Gold was found in feldspar and in kaolin derived from feldspar. At the Young American mine the presence of chalcopyrite in the ore is considered a favorable indication. Gold was identified in association with tetradymite at the Young American mine, and at the Tellurium mine it is said to occur interfoliated with that mineral. At the former mine gold was found resting on tourmaline.

Silver is usually present in traces, probably alloyed with the gold. It is said to be abundant in some of the ore at the London and Virginia mine, and argentiferous galena has been reported at the Page mine.

Pyrite is the most abundant of the ore minerals and usually carries gold values. In veins belonging to the Gold Hill system it occurs in large cubes, 1 cm. or more in diameter, but elsewhere it is fine-grained. Cubes are the commonest crystal form, pyritohedrons are also present, and octahedral faces may occasionally be identified. The pyrite rarely constitutes any considerable proportion of the quartz veins, and where it is unusually abundant the gold content is apt to be higher. Occurring as a replacement mineral in the schists and quartzite it sometimes forms 90 per cent. or more of the rock mass. At the Moss mine it occurs associated with tourmaline. Limonite is the common alteration product, and in places magnetite is associated with the pyrite in such way as to suggest its possible formation through partial oxidation of the sulphide. Unstained quartz from the Gold Hill veins frequently contains large cubical cavities from which pyrite has been wholly or partly removed. This phenomenon may be due to solution by ferric solutions or sulphuric acid instead of direct oxidation. Secondary sulphides occur along joint planes in some of the lowest workings.

Pyrrhotite is not common and occurs chiefly in altered wall rock close to the veins. Chalcopyrite is the most abundant sulphide after pyrite, but is not an important constituent except in the replacement deposits, and there it is largely secondary, occurring chiefly in zones of enrichment near water level. Chalcocite has been identified only in replacement deposits and is probably all secondary. Galena and sphalerite are both rare.

Tetradymite, a telluride of bismuth, is sparingly present at two of the mines, and the failure to identify it elsewhere is probably due to the lack of sufficient exposures as much as to its rarity. While always occurring in small quantities this mineral has been identified at many gold mines in the eastern gold belt, and seems to be one of the distinctive minerals.

Manganese minerals were not recognized in the unaltered ores below water level, but in the oxidized zone near the surface black stain (probably psilomelane) is common along joint planes and fractures.

Summary.

A number of the vein-forming minerals are of rare occurrence in gold-bearing deposits, and cyanite and soda-lime feldspar have not previously been reported. The character and association of many of the minerals are

indicative of deep-seated origin, under conditions of great pressure and high temperature. The presence of soda-lime feldspars in gold-quartz veins is of considerable importance because of its bearing on the theories of ore genesis. The occurrence of these feldspars as primary constituents in rocks has been considered the strongest evidence of igneous origin.

GENESIS OF THE DEPOSITS.

In presenting the data contained in the previous sections of this report, it has been assumed that the ores were deposited from aqueous solutions. This theory of vein formation is so well established that it is unnecessary to discuss it here. From facts which were developed in the detailed descriptions and which will later be assembled for further consideration, it is believed that the solutions were magmatic in origin.

The theory of a magmatic origin for gold-quartz veins has been developed within the last 15 years by Vogt, Spurr, Kemp, and others. The formation of this class of veins is closely related to the formation of pegmatites—a question which has interested geologists for nearly a hundred years. It would be out of place in a report of this kind to enter into a detailed discussion of the voluminous literature bearing on the subject, but, for a proper understanding of the argument which follows, it is necessary to outline the theory of magmatic differentiation in so far as it applies to vein formation.

The microscope has shown that in granites and similar rocks, the order of mineral crystallization is not that of relative fusibility; and synthetical experiments have proven that certain minerals always present in granites, can not be formed by dry fusion without the aid of water or other mineralizers. These minerals are more abundant and better developed in pegmatites—rocks which accompany and in places pass by gradation into the large granite masses with which they are commonly associated. Not only has it been found that every intermediate gradation exists between granite and pegmatite, but that pegmatites, by decrease of feldspar, pass into quartz veins, apparently similar to those which are known to be deposited from circulating solutions. The microscopic study of granites in thin sections, together with chemical analyses, proves that the mineral constituents—especially quartz, the last to crystallize—contain inclusions of primary water which was imprisoned in the solidifying rock. It is believed that the original magmas, from which granites are formed, contain water and other gases, and that as crystallization progresses these are gradually concentrated in a residuum. Pegmatites, and later quartz veins,

are formed from this residual magma as it, through partial crystallization, becomes richer in water and relatively poorer in the minerals which are of early formation. In this process of differentiation it is impossible to draw sharp lines for, as Spurr states, "At one end of the series the true granites are not wholly igneous, and at the other end the quartz veins are not wholly aqueous. The processes which formed them all are nearer together than these terms signify."[a]

The veins considered in the present report appear to be farther removed from the aqueous end of the series, and more closely allied to pegmatites than any gold-bearing veins which have previously been described. The first part of this chapter dealt with the mineral constituents of the ore-deposits, the succeeding sections will be devoted to the nature of the vein-forming solutions, their source, the conditions governing ore-deposition, and the origin of the spaces occupied by the veins.

Nature of the Solutions.

The best information as to the nature of the ore-forming solutions is furnished by a consideration of the primary minerals in the veins and the character of the changes that have taken place in the wall rock, but the absence of a sufficient number of analyses of the vein material and of the country rock, make anything other than a general discussion of the subject impossible.

Microscopic examination of the vein quartz shows that it contains numerous gas- and liquid-filled cavities, and while analyses of these fluids are not available, their composition may be inferred from that of similar inclusions in granitic quartz which have frequently been analyzed. Such inclusions have been found to consist chiefly of water containing alkaline salts and carbon dioxide. Experiments have proved that silica, gold, and the sulphides of arsenic, antimony, iron, copper, lead, and zinc, are soluble in waters containing carbonates and sulphides of the alkalies, and their solubility is probably much greater under the conditions of high temperature and pressure which obtained in the ore-depositing solutions.

The solutions must have carried large amounts of silica, and the production of feldspars and mica indicates that aluminum, sodium, calcium, and potassium were present in about the order named. The sulphides of iron, copper, zinc, and lead are all primary minerals, and were therefore essential constituents of the ore-forming solutions. Gold was also present

[a] Spurr, J. E., Ore Deposits of the Silver Peak Quadrangle, Nevada, Prof. Paper, U. S. Geol. Survey, No. 55, 1906, p. 131.

and at least some of the solutions contained bismuth and tellurium. While carbonates were noted in only a few of the veins, carbon dioxide was probably a constant constituent. The mineral tourmaline, which is of rare occurrence in gold-bearing veins, contains boron, and some geologists have attributed to this element unusual properties as a mineralizing agent. Fluorine has been found necessary for the artificial production of mica, and Spurr has suggested that the alteration, near mineral veins, of orthoclase to muscovite or sericite, is due to the presence of fluorine in the mineralizing waters.[a] The absence of orthoclase from the veins in which feldspars were identified, although a little potash mica is of common occurrence, indicates the possibility of some such action, but no fluorite, apatite, or other fluorine-bearing mineral was noted in any of the ore-deposits.

The question of the degree of concentration which obtained in the ore-forming solutions is an interesting one, but until more experimental work has been done on the synthesis of vein minerals under varying conditions, it must, for the most part, remain unanswered. It is probable that under the unusually high pressures and temperatures, which are believed to have prevailed during ore-deposition, the concentration was relatively high—how high is not known.

The presence of much soda-lime feldspar in some of the veins, and occasionally of the minerals, tourmaline and cyanite, point to unusual conditions in the formation of gold deposits. The character and association of these minerals, together with the extensive alteration of the wall rocks, are indicative of a deep-seated origin under conditions of high temperature and great pressure. The metamorphism of the wall rock in many places is similar to that produced by igneous intrusions, and is accompanied by the production of such typical contact minerals as garnet, hornblende, biotite, sericite, tremolite, and cyanite. In view of these facts it seems unquestionable that the temperature and pressure must have been much higher than those which usually prevail during the formation of gold veins. With the present knowledge of the subject any estimate of the probable temperature and pressure of vein-forming solutions must necessarily be rough, but an attempt may be of value and serve to bring out additional data bearing on the question.

Wright and Larsen, as a result of their investigations, reached the conclusion that vein and geode quartzes and coarse-grained siliceous pegma-

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[a] Spurr, J. E., Geology of the Tonopah Mining District, Nevada, Prof. Paper, U. S. Geol. Survey, No. 42, 1905, p. 231.

tites were formed below 575° C., while graphic pegmatites, granites, and porphyries were in all probability crystallized above 575°.[a] If the same relation holds in regard to the gold veins described in this report, they must have been deposited at temperatures below 575° C., and from the metamorphic effects on the wall rocks and the character of some of the vein minerals, it is believed that the temperature of the vein-forming solutions was probably above the critical temperature of water, which is about 365°.

Becker, Graton, Lindgren, and others have recognized that the southern gold veins originally extended far above their present outcrops and it has been estimated that a depth of possibly 15,000 or 20,000 feet may have been removed by erosion.[b] Taking the average specific gravity as 2.7, the rock pressures at these depths would be, respectively, 17,550 and 23,400 pounds per square inch. From facts which will be considered in detail in discussing the origin of the spaces occupied by the veins, the writer believes that the veins were formed in the zone of fracture and flowage as defined by Van Hise. There is evidence that, at the time of vein formation, hard quartzites were deformed chiefly by fracturing, while the softer rocks with which they are interbedded, adjusted themselves to unequal strain by flowing. The schists exposed at the Tellurium mine are the weakest rocks found enclosing veins, and their crushing strength is probably greater than that of good roofing slates, for they have undergone greater recrystallization. The crushing strength of strong slates averages from 15,000 to over 30,000 pounds per square inch. While the figures given above are only roughly approximate they serve to indicate the great pressures which prevailed during the formation of the veins. For the rocks under consideration the higher figure is probably more nearly correct.

Source of the Material.

The composition of the gold-bearing veins is independent of the character of the wall rock, which varies greatly in different localities; and therefore it is improbable that the vein material could have been derived from the enclosing formations. On the other hand, the composition and texture of some of the veins closely resemble that of pegmatites, and it is difficult, if not impossible, to account for the presence and association of such minerals as tourmaline, magnetite, ilmenite, and much soda-lime feldspar, on any hypothesis other than that of magmatic origin.

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[a] Wright, F. E., and Larsen, E. S., Quartz as a Geologic Thermometer, Amer. Jour. Sci., 1907, vol. xxvii, pp. 446-47.

[b] Lindgren, W., Notes on the Dahlonega Mines, U. S. Geol. Survey, Bull. 293, 1906, p. 124.

Additional evidence in favor of this hypothesis is furnished by the alteration of the wall rock, an alteration which in places resembles on a small scale the contact metamorphism produced elsewhere in the area by the intrusion of granite into older sedimentaries. The great depth at which the veins were formed and the conditions of high temperature and pressure which must have prevailed, have already been discussed. It is obvious that the solutions from which the ore-bodies crystallized must have originated at points of even higher pressure and higher temperature; for in moving upward the pressure would decrease, and some heat be expended in raising the temperature of the surrounding rocks. These conditions would be fulfilled if we assume the presence of an underlying mass of igneous rock, and this conclusion was reached by an entirely independent line of reasoning (see pp. 102-103).

An examination of the geological maps (Pls. I and II) shows that most of the gold-bearing veins are distributed in belts that roughly parallel the known contacts between intrusive granite and older sedimentaries. In the chapter on structure and metamorphism evidence was presented in support of the hypothesis that the veins are located chiefly along the limbs of anticlinal folds, and that the underlying granite extends highest in the crests of these folds.

Another line of argument helping to prove a connection between the veins and granite is furnished by evidence bearing on their relative age—evidence which indicates that the formation of the veins marked the close of the period of granite intrusion and that they were not improbably contemporaneous in origin with the pegmatites and other residual differentiates.

If the solutions that deposited the ore-bodies were derived by differentiation from the original granite magma, the granite itself would be expected to contain some gold, although the quantity might be so extremely small as to make its detection difficult and its quantitative determination impossible. Two samples of granite were tested in order to ascertain, if possible, the presence of any gold. One of these samples consisted of gneissic granite from the quarry at Columbia, and upon assaying it gave negative results. The other was obtained from an outcrop of weathered granite on the farm of H. Williams, one mile northeast of Rivanna Mills. After removing several inches of the partly decomposed rock in order to insure against possible contamination, an average sample was taken over an area of several square feet, and this was quartered down to give a final sample of about 5 pounds. A careful assay of this yielded 0.015 ounce of gold per ton, equivalent to about \$0.31.[a]

[a]These two assays were made by E. E. Burlingame & Co., Denver, Colorado.

In prospecting for gold, a 15-foot shaft was sunk on a pegmatite dike, located about 400 yards north of the granite outcrop described above. The pegmatite is partly fine-grained, but contains large angular masses of quartz showing a little pyrite (see sketch, p. 74). Mr. Williams states that some of this quartz assayed nearly $3.00 gold per ton.

The results given above prove that the granite does carry gold in places, and while it would be rash to draw conclusions without taking a large number of samples, it is interesting to note that the granite in which gold was identified, is the porphyritic variety showing only slight schistosity, and that it is located near the crest of the hypothetical anticline (see pp. 98-99), at a point where the granite is believed to have been formerly covered by schists at no great distance above the present surface.

Deposition of the Ores.

The manner in which ores are deposited and the causes which bring about precipitation are of the utmost importance in any consideration of their genesis, but exact knowledge on this subject is as yet very limited. In this district, the inaccessibility of most of the underground workings, which confined the detailed examination of ore-bodies to a very few localities, and the lack of a sufficient number of analyses, necessitates that the discussion of this subject be extremely limited.

The precipitation of ores from solution may be brought about by any one of the following causes, or by two or more of them acting together:

(1) Change in temperature.
(2) Change in pressure.
(3) Change in chemical composition due to
  (a) loss of some substance from the solution;
  (b) mixture with other solutions;
  (c) reaction between the wall rock and solution.

It has been shown that the temperature and pressure of the ore-bearing solutions must have been higher at the points of origin than they were where deposition took place. Decrease in temperature was probably the chief cause in bringing about the separation of the gangue minerals, and possibly of the ore minerals as well. The effect of changes in pressure is not so well known, but certainly in the case of quartz, decrease in pressure is an important factor in causing supersaturation. The separation of some of the gangue minerals may have altered the composition of the solutions to such an extent that other minerals were thrown down. It is doubtful

whether the solutions mingled to any extent with other solutions differing in chemical composition, for meteoric waters could hardly be abundant at a depth where the pressure was sufficient to prevent the formation of appreciable openings.

Reaction between solutions and wall rock seems to have been an extremely variable factor in the deposition of the ores, and while these variations may in part be explained by differences in the character of the wall rock, many things indicate that there was probably considerable difference in the composition of the ore-forming solutions in different parts of the district. North of James River there is little evidence of important changes in the chemical composition of the wall rock. In places there has been considerable metamorphism, resulting in recrystallization and the formation of new minerals, but the changes in chemical composition are comparatively slight, and are chiefly due to silicification. Sulphides have replaced some of the minerals in the wall rocks but usually to a very limited extent.

In some of the ore-deposits south of the river, such as the London and Virginia vein, chemical interchange between the solutions and wall rock has been of the utmost importance. Porous rocks are of course most readily penetrated by solutions, and this may help to explain the occurrence of the replacement deposits in quartzites and quartz schists. In these deposits the chief replacement mineral is pyrite. The iron-bearing minerals in the country rock seem to have been attacked first, but in places practically all of the quartz has been replaced. Feldspars, if present, were altered to sericite, and this mineral is about the only gangue mineral left in some of the ores that are most concentrated.

While nothing definite is known concerning the rate of ore deposition, the formation of the deposits was probably exceedingly slow and extended over a considerable period of time. This is indicated by facts connected with the probable manner in which the spaces occupied by the veins were formed—a question which is considered in detail in the following section.

Origin of the Spaces Occupied by the Veins.

Formerly it was generally believed that all true veins were deposited by aqueous solutions circulating through preëxisting fissures. That some veins were formed in such openings is indicated by the presence of symmetrical banding, comb structure, and similar evidence, but in recent years doubts have arisen as to whether all veins could have been formed in this manner. The theory of replacement is applicable in many cases but

does not furnish a satisfactory explanation of the origin of veins which are accompanied by little or no replacement of the wall rock.

As early as 1898, Russell, in describing certain "brecciated veins," stated that the separation of the rock fragments "seems to be due in part, at least, to the crystallizing of the quartz and calcite." He suggests "that these minerals, in crystallizing, have exerted a force analogous to the expansion of water on freezing, which has crowded the rock fragments asunder."[a]

The fact that growing crystals exert a linear pressure in the direction in which they grow, was noted by Jean Lavalle in 1853,[b] but no quantitative experiments seem to have been attempted until Becker and Day began their investigations. In 1905, Becker and Day, as a result of their experiments, stated: "It was at once evident that it [the linear force of growing crystals] amounted to many pounds per square inch, and as observations multiplied, it became reasonably certain that it is actually of the same order of magnitude as the ascertained resistance which the crystals offered to crushing stresses."[c] In conclusion they called attention to the geological importance of the force of crystallization and pointed out the possibility of its action in widening quartz veins.

Graton, in studying the gold-quartz veins in North and South Carolina, reached the conclusion "that the solutions, pushing their way along what may in many cases have been the merest fractures, actually forced the walls apart and made receptacles in which their load was deposited."[d]

Lindgren, advocating the explanation advanced by Graton as opposed to the hypothesis that veins could be formed through the force of crystallization, states that "it scarcely seems possible to attribute such power to it as would be necessary to force deep-seated crevices apart to form room for the crystals, and another strong objection is that it would seem impossible that under these conditions comb structure and coarsely even-grained quartz could be produced."[e]

The study of veins in the Virginia area, and especially of those exposed at the Tellurium mine, has convinced the writer that the force

[a] Russell, I. C., A Preliminary Paper on the Geology of the Cascade Mountains in Northern Washington, 20th Ann. Rept. U. S. Geol. Survey, 1898-99, pt. ii, p. 207.

[b] Compt. Rend., 1853, vol. xxxvi, p. 493.

[c] Becker, G. F., and Day, A. L., The Linear Force of Growing Crystals, Proc. Washington Academy of Sciences, 1905, vol. vii, pp. 286-287.

[d] Graton, L. C., Reconnaissance of Some Gold and Tin Deposits of the Southern Appalachians, U. S. Geol. Survey, Bull. 293, 1906, p. 60.

[e] Lindgren, W., The Relation of Ore-Deposition to Physical Conditions, Economic Geology, 1907, vol. ii, p. 107.

exerted by growing crystals must have been the chief factor in the formation and enlargement of these gold-bearing veins. A discussion of the facts on which this conclusion is based, is given below.

The "Middle" vein at the Tellurium mine consists of a series of lenses, varying in size, but remarkably symmetrical in form (see figs. 13-15). Horizontal sections through these lenses resemble the vertical sections in every way. The wall rock is a fine-grained, highly foliated schist containing scattered crystals of garnet, and closely approaches a slate in perfection of cleavage and fineness of texture. The schistosity is parallel to the bedding and older than the formation of the vein, which is conformable in strike and dip. Thirty feet northwest of the "Middle" vein the schist is interbedded with a layer of quartzite about 6 feet thick, known as the "Big Sandstone" vein. This quartzite is also slightly schistose parallel to the bedding. It encloses veinlets similar in composition and texture to the "Middle" vein and evidently formed at the same time and in the same manner, but these veinlets frequently cut across the schistosity of the enclosing rock (see fig. 12). A detailed description of these veinlets and of the "Middle" vein, together with a petrographic description of the wall rocks, is given on pages 157 to 170.

The fact that the veins of this district show practically no crushing or other evidence of deformation, although the surrounding country rock is intensely foliated, is sufficient proof of their formation since the crustal movements that produced the schistosity, and moreover in some of the harder rocks they occasionally cut directly across the prevailing schistosity.

The space occupied by lenticular veins is sometimes accounted for on the supposition that displacement has occurred along an irregular fault, but in the case of veins like the "Middle" vein, this explanation would be improbable, in view of the symmetrical shape of the lenses, which is the rule even where adjoining lenses differ greatly in size. This argument is confirmed by the fact that the folia of the enclosing schist, where in contact with the vein, conform absolutely to the curvature of the lenses. It may also be mentioned that single detached lenses are occasionally present near some of the veins (see Pl. X, fig. 2) and such occurrences can not be explained by any method of faulting. In passing away from the lenses the flexures in the schist gradually straighten, so that at a distance of about 2 feet the cleavage is straight and uniform.

From the facts stated above, it is concluded that the "Middle" vein could not have been formed in a preëxisting fissure, and since the contacts with the wall rock are sharp and without evidence of replacement, the

lenticular spaces must be due to pressure. That the rock pressure during vein-formation was greater than the crushing strength of the schist, is proved by the uniform curves of the folia—the schists have made room for the lenses by flowing and not by fracturing. The faint line connecting the lenses shows that the ore-bearing solutions, following the lines of least resistance, entered along the planes of bedding and cleavage; but great pressure was necessary to expand such microscopic openings into lenses 2 or 3 feet in thickness. How could such a pressure be developed?

There are two hypotheses that may be advanced to account for the existence of such pressure: (1) The ore-bearing solutions were forced in from below under sufficient pressure to push the walls apart, and (2) the pressure was exerted by the crystallization and growth of the vein-forming minerals.

The chief argument against the first hypothesis is the symmetrical and, in places, almost spherical shape of the lenses. If the expansion of the openings was due to fluid pressure exerted by the ore-bearing solutions, the pressure would necessarily have been equal at all points of contact between the fluid and the walls, except for the slight variations due to friction and difference in elevation. The enclosing schists are apparently uniform in texture and composition, and therefore would offer uniform resistance to the fluid pressure at all points, except those lying in the plane of cleavage along which the solutions entered. Under these conditions very flat lenticular- or tabular-shaped openings must have been formed. In explaining, by means of this hypothesis, the formation of a series of openings similar to the lenses shown in figs. 13 and 15, it would be necessary to assume the presence of areas of unusual weakness at every point where an enlargement of the vein occurred. Moreover, since most of these enlargements are symmetrical, it would be necessary to assume that, at these points, there were similar areas of weakness on both sides of the cleavage plane. Such assumptions are almost inconceivable.

Unless the spaces were filled by ore-deposition as soon as formed, the fluid pressure would have to be uniformly maintained in order to prevent the walls from collapsing. The great fluidity of the solutions is indicated by the microscopic size of some of the openings along which they entered. Additional evidence against the formation of the openings by fluid pressure is furnished by the existence of large lenses, consisting of a number of smaller quartz lenses separated by feldspar and layers of schist. (See fig. 14.)

In a previous paragraph it was mentioned that the veinlets occurring in the bed of quartzite frequently cut across the schistosity. This is ex-

plained by the greater rigidity and more nearly massive texture of the quartzite which caused it to rupture under the forces of deformation while the weaker schist yielded by flowing. In other words, the rigidity of the quartzite under the conditions of vein-formation was probably greater than the rock pressure, while that of the schist was less. The line of least resistance for the ore-bearing solutions which entered the quartzite was frequently along minute fractures instead of along the poorly developed cleavage planes, and therefore the veinlets do not always conform to the structure of the enclosing rock. If the spaces occupied by the veins are due to fluid pressure, it is difficult to understand why veins a foot or more in width were formed in the quartzite, when the less rigid schist was present on either side. Under these conditions veins might be expected along the contact between the quartzite and schist, or wholly within the schist, but not in the quartzite.

In view of all of the facts outlined above, it seems very improbable, if not impossible, that the vein spaces could have been produced by fluid pressure and then filled by ore-deposition.

According to the second hypothesis, the solutions entered along narrow openings—probably capillary or subcapillary in size—and while under pressure, the pressure was insufficient to expand the openings. Crystallization began at favorable points, possibly about grains of quartz, and as the crystals grew, the walls were locally pushed aside. At first a growing lens may have consisted of a single crystal, but as the folia began to separate, others would form in the space created immediately around the original crystal, where the pressure was lowered by its supporting effect. Since the resisting pressure was equal on opposite sides of the cleavage plane the growth would be symmetrical with reference to that plane. When once started a lens would continue to grow as long as the material for growth was available.

There are many points of similarity between the formation of these lenses and the growth of chert concretions in limestones, or of garnets and similar pseudophenocrysts in fine-grained schists. The localization of growth is probably due to the physico-chemical law by which solutions become supersaturated with respect to large crystals, while at the same time they may exert a solvent action on small crystals of the same substance.

When individual crystals are enlarged their shape is controlled by the tendency to form crystal faces, by the external forces resisting growth, and by the accessibility of the material from which they are composed. When

masses, consisting of numerous crystals, are enlarged by crystal growth, the resulting shape is controlled chiefly by the forces resisting expansion. The schist enclosing the lenses described above has a much greater tensile strength parallel to the schistosity than across it, and the folia offer considerable resistance to rupture, even when the rock is under sufficient pressure to make it more or less plastic. The resistance offered by these folia to the enlargement of the ore-bodies is somewhat analogous to surface tension, which in liquids causes the assumption of shapes giving a maxi-

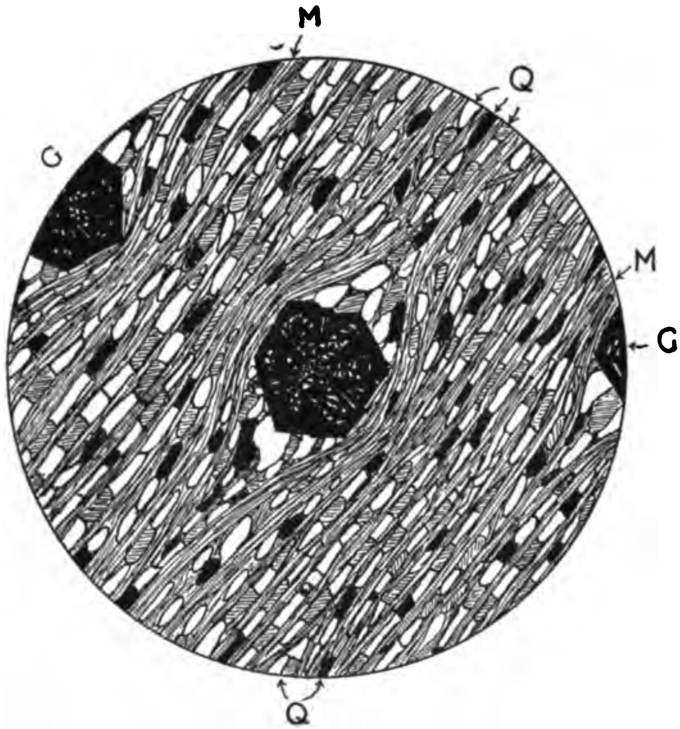

Fig. 21.—Sketch showing recrystallization of quartz about garnets which are of later origin than the foliation of the schist. Thin section cut at right angle to cleavage. With analyzer. *Q*, quartz; *M*, mica; *G*, garnet. Enlarged about 20 diameters.

mum volume for a minimum exposure of surface. The solubility of quartz decreases with decrease in pressure and supersaturation is reached first where the pressure is lowest. If the resistance to growth were equal in all directions spherical bodies would be formed instead of lenses, and under any given condition the shape produced is that shape which requires the least expenditure of energy.

The fact that difference in pressure may be an important factor in determining the location of crystal growth, is strikingly illustrated by the recrystallization of quartz around the garnets occurring as pseudophenocrysts in the knotted schists of the area. These schists form the wall rock of the "Middle" vein, and it should be noted that where this variety of garnet schist has been found elsewhere in the area, it occurs only in the immediate vicinity of granite contacts. The garnets are of later origin

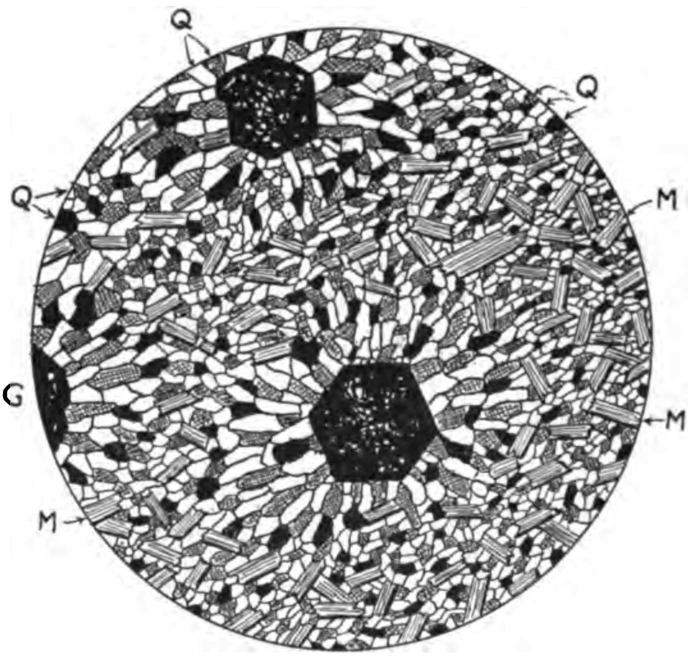

Fig. 22.—Sketch showing radial arrangement of quartz in garnetiferous schist. Thin section cut parallel to cleavage. With analyzer. *Q*, quartz; *M*, mica; *G*, garnet. Enlarged about 15 diameters.

than the schistosity of the rock, and it is believed that their formation in the schist at the Tellurium mine, is due to the close proximity of granite rather than the metamorphic action of the vein-forming solutions. In either case their origin must have been practically contemporaneous with the formation of the veins. Under the microscope the schists are seen to consist essentially of elongated quartz grains and small flakes of mica, the two minerals being interleaved to form thin layers or imperfect alternating bands. The garnets in their growth have pushed the folia aside,

and opposite the points of greatest pressure the mica bands run closer together, while the quartz removed from these points has recrystallized between the folia and close to the garnets where the pressure was least. (See fig. 21.) The transfer of the material was undoubtedly due to the small amount of water present in the rock; solution occurred where the pressure was greatest and deposition where it was least. In recrystallizing the quartz grains were roughly oriented so that their greater elongation points toward and away from the garnets. (See fig. 22.)

The partial concentration of feldspar near the ends of quartz lenses, and in small separate lenses practically free from quartz, is caused by the selective power which enables a growing crystal to abstract from solutions material like itself; and this may be taken as additional evidence in favor of the second hypothesis.

An examination of the lenticular veins show that in some instances neighboring lenses in expanding have grown into one another so as to form double lenses, and it is not unlikely that other occurrences of this sort have disappeared through continued growth. The large lenses composed of smaller ones, such as the occurrence shown in fig. 14, were probably caused by the circulation of the ore-forming solutions along several adjoining cleavage planes at the same time, thus permitting the simultaneous growth of lenses at a number of points close together. An alternative hypothesis is that the solutions were deflected into new channels after a lens had been formed causing subsequent deposition to take place about other nuclei located between adjacent folia.

In describing the veinlets occurring in the quartzite, reference was made to the absence of the symmetrical lenses which are characteristic of the vein in the schist. This difference in the shape of the ore-bodies is probably chiefly due to the difference in texture and rigidity of the two varieties of wall rock. If crystallization began at separate points along the fractures in the quartzite and exerted a force tending to open spaces, the rigidity of the rock was sufficient to cause the walls to separate for an appreciable distance beyond the points where the pressure was applied. Any openings formed in this way were filled by deposition from the solutions, and therefore the tendency was to form veins without important variations in width. In other words, rigidity of the wall rock under the conditions of ore-deposition is an essential factor in the formation of veins having a uniform width. This is another illustration of the law controlling the growth of bodies by crystallization, in opposition to outside forces.

The composition of the quartzite has probably aided in producing uniformity in the growth of the veins which it encloses, and this may have

been of as much importance as the rigidity. Since the quartzite is composed almost entirely of quartz grains, the walls of the fractures would furnish innumerable nuclei on which the vein quartz could separate out. In thin sections showing the contact between the quartzite and vein quartz, when examined under the microscope, it may be seen that the quartzite grains along the contact have been enlarged, and that there is therefore a gradation instead of a sharp division in passing from one to the other.

Under the conditions which prevailed during the vein-formation, the gneiss, which forms the wall rock at the Young American mine, appears to have been intermediate in rigidity between the quartzite and knotted schist described above. It was folded and contorted by movements preceding the deposition of the ores, and adjustment took place partly by flowing and partly by minor faulting along fractures and shear zones. The vein-forming solutions entered along these lines of weakness and the enlargement of the openings was brought about by the same causes that operated at the Tellurium. In the gneiss, most of the small quartz masses and some of the larger ones are lenticular in form, but these lenses are flatter and as a rule less symmetrical than those of the "Middle" vein at the Tellurium. They are most plentiful in some of the shear zones. (See fig. 9, p. 130, and Pl. X, fig. 2.)

The hypothesis that vein spaces may be enlarged through the force exerted by growing crystals, furnishes a logical explanation for the presence of numerous detached fragments of the country rock in the veins of some districts. These occurrences have usually been explained on the supposition that the veins were deposited in preëxisting fissures, and that the inclusions represent fragments which have fallen from the walls. That this is sometimes true can not be questioned, though it seems probable that such cases are relatively rare. Where the country rock has been shattered so that numerous small fractures are formed, ore-deposition may take place in any number of them at the same time, and as the veinlets grow the individual fragments of country rock are gradually separated. According to this hypothesis of vein-formation there is no essential difference between the cementation of many breccias and the formation of branching or reticulated veins. The processes by which both are formed are exactly the same and differ only in degree.

At the Morrow mine, in Buckingham County, ore-deposition seems to have occurred in a zone of fracturing; in places the ore-body consists of vein matter with minor inclusions from the walls, while elsewhere the ore occurs in reticulated veinlets which ramify in all directions through the

barren schists that form the country rock. All gradations exist between these two extremes. (See fig. 20, p. 204.) The detached masses of country rock have apparently reached their present positions without noticeable rotation, for as a rule the schistosity of the inclusions is parallel to that of the neighboring walls.

The localization of the veins of this district in or near the more rigid rocks, especially quartzites, is very noticeable, and may indicate that at greater depth where the pressure was necessarily greater the solutions were unable to force their way through the fine-grained and more plastic rocks. The greater porosity of the quartzites may also have been a factor.

General Conclusions as to the Origin of the Gold Deposits.

The primary gold deposits of this area, while varying somewhat in general character, are all intimately related, and owe their origin to the same cause, namely, the intrusion of granitic rocks into the older sedimentaries. They are of two types—quartz veins and replacement deposits—with intermediate gradations between the two extremes. The ores were deposited from highly siliceous and alkaline solutions which ascended from below under great pressure and high temperature. The solutions were magmatic in origin and residual from the crystallization of the underlying granite. This conclusion is borne out by the grouping of the ore-deposits around granite contacts; by the presence and association in the veins of soda-lime feldspar, tourmaline, magnetite, and ilmenite; by the metamorphism of the wall rocks with the production of such typical contact minerals as garnet, hornblende, biotite, sericite, tremolite, and cyanite; by the presence of gold in the granite and its associated pegmatites; and by the evidence as to the relative age of the granites, pegmatites, and veins. It is believed that the precipitation of the ores was due chiefly to decrease in temperature and pressure, though in the replacement deposits interchange of material between the solutions and country rock was an important and perhaps the principal factor.

The ores were deposited at great depths below the surface where the pressure of the overlying rock was sufficient to prevent the formation of open spaces appreciable in size. The solutions forced their way upward along cleavage planes and, in the more rigid rocks, along minute fractures. When deposition began these spaces were gradually expanded by the force of crystallization. The formation of the replacement deposits was probably due to differences in the ore-bearing solutions, but the character of the country rock may have had a determining influence.

The veins in this district differ markedly from the typical auriferous quartz veins of California, which many geologists regard as having been formed by magmatic waters derived from cooling granites. The California veins are much later in origin, have been subjected to less erosion, and therefore their present outcrops were much nearer the surface when ore-deposition took place. This suggests that many of the distinguishing characteristics of the two types are due to the depth below the surface at which the veins were formed. It is not improbable that at greater depth the California veins more closely resemble the gold deposits described in the present report, and that the upper portions of the Virginia veins, long since removed by erosion, were in many respects similar to the veins which are now being worked for gold in California.

SECONDARY ENRICHMENT.

The distribution of the gold in the ore-deposits is a question of great economic importance, and it is regretted that so little is known concerning the subject. The lack of sufficient development work at any of the mines, which were accessible when the area was studied by the writer, makes it impossible to reach definite conclusions in regard to secondary enrichment, and therefore the following discussion is necessarily brief.

The facts gathered indicate that the gold is very irregularly distributed through the veins. There appear to be more or less well-defined pockets or ore shoots of relatively rich ore, but the size and distribution of these is unknown. It is probable that the values vary from point to point in depth as well as along the strike of the veins, and this increases the difficulty of ascertaining the extent to which secondary enrichment has been a factor in determining the present value and distribution of the ores.

It seems unquestionable that the veins were much richer near their outcrops than they are at even a short distance below the surface. The greater production of the mines when they were first worked can not be attributed solely to the fact that the ores were oxidized, and therefore free-milling, for the reports of such reliable observers as Silliman, Ansted, and Henwood, furnish evidence of the unusual richness of the veins when the mines were first opened. Henwood, in describing the Morrow mine, expressed his belief that the gold values decreased in depth (see p. 205), and cited the statistics of production in support of this contention. Ansted, in his report on the same property, mentions that near the surface the gold is indifferently disseminated through the quartz, rotten schists, and enclosing walls, while deeper down it gradually collects together and is found

chiefly within the quartz bands. This local enrichment of the vein and wall rock near the surface, is probably due chiefly to the mechanical concentration of some of the gold formerly contained in the now eroded portions of the ore-bodies, though it is not unlikely that chemical processes have aided in the concentration. Gold is one of the most insoluble substances found in nature, but the long period during which erosion has been almost at a standstill has given every opportunity for concentration to take place through solution and redeposition. Most of the gold that may have been dissolved in this manner was probably reprecipitated before it had been carried far, for precipitating agents were plentiful.

In some of the deeper openings which extended below the oxidized zone, secondary pyrite is found occurring along joint planes and fractures, but the development work is insufficient to determine whether or not there has been any enrichment of the gold values at this depth.

AGE OF THE ORE-DEPOSITS.

Geologists have usually assumed that all the primary gold deposits in the Southern Appalachian region belong to the same metallogenetic epoch. While it is not improbable that this is true, it has not, as yet, been established by sufficient detailed geological work. Many of the older geologists considered the veins contemporaneous with the enclosing rocks which were classified as "primary." Becker and most of the recent workers have placed the deposits in the pre-Cambrian.

The veins in the district covered by the present report, were formed after the intrusion of the granite, and probably represent the final stage in the period of igneous activity which preceded their deposition. They show no evidence of having been subjected to the great crustal movements which so intensely metamorphosed the enclosing sedimentary rocks and even the massive granites. These movements were probably inaugurated and the sedimentaries rendered schistose prior to the intrusion of the granites with which they are in contact. The well-developed schistosity of most of the granitic rocks is evidence that the movements continued throughout the greater part of the period covered by their intrusion. The porphyritic facies of the granite show decreasing pressure effects and many of the pegmatites are practically massive. These facts are discussed at greater length in the chapter on structure and metamorphism.

The profound changes to which the ore-bearing formations were subjected prior to the intrusion of the granite, indicate that a considerable time interval must have intervened between the deposition of the sedi-

ments and the formation of the veins; and this together with the lack of important crushing, or other evidence of disturbance in the quartz veins, suggests that they are later than pre-Cambrian in age.

Subsequent to the intrusion of the granite and the formation of the gold veins, sufficient time elapsed for erosion to remove the overlying material and expose the deep-seated granite, before the surface was again depressed to receive the sediments of late Ordovician time. The Arvonia slates, which are known to be Cincinnatian in age, were laid down on the older schists and in places on granite which is only slightly schistose. Therefore even the granites which were last to solidify are older than Cincinnatian in age. The slight evidence of dynamic metamorphism exhibited by the gold-bearing veins was probably induced by the movements which elevated and folded the Ordovician sediments.

A consideration of the facts outlined above makes it appear reasonably certain that the primary gold deposits in the James River basin are older than Cincinnatian in age, and they are probably younger than pre-Cambrian. Until further evidence is available, the writer is of the opinion that the veins should be classified as Cambrian.

CHAPTER VII.

PLACERS.

Gold has been found in the gravels of all streams that cross the gold-bearing rocks of this area, and also in certain ancient stream gravels that are now located high above the neighboring water-courses. Most of these "branch" gravels, as they are locally called, have been worked, and some of them reworked a second time in order to recover the precious metal which they contained. Gold also occurs, concentrated in considerable quantity, in the accumulations of residual decay overlying the gold-bearing veins and in their immediate vicinity, and such deposits have been profitably worked in a number of places.

When the gold-bearing veins and the enclosing country rocks were exposed by denudation to the chemical and mechanical action of the agents of erosion, the slow process of concentrating the heavier and more resistant constituents into the placer deposits began, and this has been in continuous operation ever since. The minerals with least resistance are attacked first, their decomposition making easier the disintegration of the remainder, and under this process the rocks slowly go to pieces. If the products of weathering collect faster than the streams can transport them, deep residual soils are gradually formed. Of the common minerals, quartz is the hardest, the least soluble, and does not undergo chemical decomposition; and since it is the principal vein-forming mineral, the veins usually extend for some distance above hard rock into the overlying mantle of residual decay, but frost and plant roots step by step break up even the larger veins and add their constituents to the soil.

With the breaking down of the rocks and the formation of disintegrated material, the next step in the process of concentration is that of sorting and transportation. Expansion and contraction, due to changes in temperature and to freezing and thawing where water is present, cause the soils to gradually creep down hill. The wash of rain water aids in this slow movement by carrying off the lighter particles, while the heavier fragments lag behind. In this way a partial concentration of the heavier constituents in the residual decay is brought about, and as gold has a very high density and is relatively insoluble, it frequently occurs in considerable quantity in the decomposed material lying vertically above gold-bearing veins, and along the hill slopes immediately below them. The gold found

in such localities has not traveled far and is therefore comparatively rough and angular, while the quartz and other rock fragments which may accompany it do not show the rounded waterworn surfaces of stream gravel. Deposits of this nature have been worked in a number of places, notably at the Tellurium and Waller mines where they are said to have been very rich.

The slow creep of the soil and occasional heavy rains gradually bring the products of disintegration within reach of running streams, which continue the work of concentration, but here an additional process is brought into play—that of abrasion. The swiftly flowing streams rapidly remove the finer sediments in suspension while the heavier fragments are rolled along more slowly by the current, constantly striking and grinding against one another. This continual impact and friction, in time, is sufficient to wear away the toughest rocks, and quartz while hard is rather brittle. The gold, being malleable, escapes most of this comminution, and because of its high specific gravity settles through the sand and gravel until it finds lodgment close to bedrock. In this manner the placer deposits are gradually formed in the stream beds.

If for any cause the course of a stream is changed, the placer gravels which have been formed in its bed may remain as deposits of dry gravel which, as the stream deepens its channel, are left high above the water level. Placer gravels of this type were at one time extensively worked on the Collins place, a mile northeast of Lantana.

As a result of the hammering which they have undergone, the gold nuggets found in placer deposits are smooth and rounded, differing in this respect from those found closer to the original vein deposits. The placer gold is, moreover, somewhat purer or of a higher degree of fineness than the vein gold, for during the long time in which it has been subjected to the oxidizing and solvent action of the agents of weathering, impurities have been largely removed. In other words, the gold has passed through a sort of natural refining process as well as one of concentration.

The unusual richness of the branch gravels as compared with the original vein deposits from which they were derived is due to the great length of time in which the process of concentration has been going on, the large amount of material which has been worked over, and the very limited extent of the gold-bearing gravels formed.

The area has probably been subjected to erosion almost continuously since the close of Ordovician times, and this has affected the gold deposits ever since the veins were first exposed by degradation. Everything bearing

on the genesis of the gold veins, as has been stated in detail elsewhere, indicates that the portions of the veins that are now exposed, were formed at a great depth below the surface; and a study of the physiography of the area gives independent evidence as to the thousands of feet of overlying rock removed by erosion. The veins, when formed, must have extended several thousand feet above the present surface, and while most of the gold originally contained in this vast amount of material was probably carried away and lost, a considerable proportion of the metal, because of its toughness, resistance to ordinary solvents, and high specific gravity, has been retained and concentrated into the relatively small bulk of material composing the placer gravel deposits.

The placer gravels of Virginia are limited to the immediate vicinity of the vein-deposits from which they have been derived, and nowhere do they cover large areas, being almost entirely confined to the branches and smaller creeks. Much of the placer gold is coarse, and this together with its comparative roughness indicates that it has not traveled far. The branches are frequently reported to have been richest near the veins, and none of them was worked for any great distance below the lowest known veins, usually less than a mile. They carried little or no value above the veins, and in fact many of the veins, which seldom outcrop, were located by panning up the branches. Large deposits of low-grade gravels, such as those in California which were extensively worked at one time by hydraulic methods and are now being worked by dredging, have not been found in Virginia. The only place within the present area where it would be possible to find similar gravels is in the Triassic beds, which are exposed near the southern boundary of the area. It is interesting to note that Becker, working in a similar district, found transported gold in the Newark (Triassic) conglomerates of North Carolina.[a]

During the time in which the present branch gravels were being concentrated, the physiographic conditions in Virginia were not suitable for the formation of low-grade placers. The fact that approximate peneplaination has continued for a long period of time is probably the reason that large deposits of auriferous gravels are absent and that the placer gravels are all concentrated close to the primary deposits. The factors which make the Virginia branches such perfect "concentrators" having been outlined above, it might be of interest, for purposes of comparison, to state briefly the conditions under which the large low-grade deposits of California were formed.

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[a]Becker, Geo. F., Reconnaissance of the Gold Fields of the Southern Appalachians, 16th Ann. Rept., U. S. Geol. Survey, 1894, pt. iii, pp. 315-316.

In California the mountain streams crossing the gold area are swift, and consequently their powers of transportation high; the rainfall is light, but largely confined to certain seasons of the year when sudden floods are not uncommon. The result of these conditions is to give a maximum of transportation efficiency for a given volume of water, and the streams are able to carry down vast quantities of gravel and even boulders of considerable size. When the streams, however, reach lower elevations and enter the large valleys that stretch back from the coast, their velocity is checked and their power of transportation suddenly diminished, causing them to drop a large part of their load. In this way gravel deposits, which often cover large areas to a depth of 30 or even 100 feet or more, and which in places contain small quantities of irregularly distributed gold, have been built up in some of the valleys.

The placer gravels were extensively worked during the early days of mining in the James River district, and in many places they are reported to have been very rich. At this late date no authentic records are obtainable that would give the amount of gold produced by the placer deposits of this district, or even of the State as a whole, but it is unquestionable that a very large percentage of the total gold production in Virginia has been derived from the gold-bearing gravels. While most of these branch gravels were worked out years ago, it is still possible to estimate the extent of the deposits from the irregular piles of gravel that were always left behind.

In this section all known placer deposits that could be profitably worked by the simple methods formerly employed, were long ago exhausted, and it is improbable that new ones will be discovered in the future. In regions, such as this, which have long been inhabited, one can no longer expect to find rich, easily workable placer gravels, and this is especially true in a section where the presence of gold has been known for so many years, and where so much prospecting has been carried on. The presence of gold in such deposits is so easily detected, even by those with little experience, that there is little likelihood of its being overlooked, and the methods that may be used to recover it are so simple and inexpensive that the deposits are quickly worked out.

Much gold was lost by the wasteful methods commonly employed when the branch gravels were first worked, and it would probably pay to rework many of these deposits, if a suitable method could be devised for handling them cheaply on a large scale. In the early days of mining the branches were usually leased, and the gravel washed in rockers by tributers who

payed a certain percentage of the gross proceeds, as a rule a fifth of the gold recovered. Some gold escaped recovery or was overlooked, and when the gravels were poor or mixed with sufficient clay to make washing difficult they were left untouched. Panning shows considerable gold even in the gravels that have been washed, and these also contain some mercury and amalgam lost by the early miners. Most of this gold is fine but it is granular and easy to recover; the gravel is small in size, contains but little sand and there are no boulders. In most places the grade is not sufficient for sluices.

The only known placer gravels which have not been worked are those that occupy the bed of Byrd Creek and in places underlie the adjacent low-lands, but up to this time the difficulties involved in the profitable handling of these gravels have proved insurmountable. While they have not been systematically prospected, it seems certain that the Byrd Creek placer gravels must contain much gold. Byrd Creek is one of the larger streams of the area, and it cuts directly across the gold belt, while its tributaries include most of the rich branches formerly worked for gold.

So far as known the only effort to work the Byrd Creek gravels was made about the year 1900. During the summer, while the water was low, an attempt was made just above Bowles' Bridge, 4 miles northeast of Columbia, to turn the creek aside, sink pits down to bedrock in the stream bed, and wash the gravel in rockers, but this experiment proved unsuccess-ful, for the water could not be kept out and the pits soon caved. It is said that the gravel was about 7 feet deep and that there was no overburden of mud; bedrock looked like slate and was covered with a layer of soft, decom-posed rock that made shoveling easy. The gold was coarse, most of it being "about the size of wheat grains." The conditions may have been unusually favorable at this place as a branch that had rich placer gravels entered the creek not far above.

The only other information bearing on the value of the Byrd Creek gravels is furnished by some prospecting done on the Bertha and Edith tract, which lies on the east side of the creek 3 miles northeast of Columbia. All the branch gravels on this place were washed for gold years ago, and the placers along Great Camp and Maple branches are reported to have been very rich. At that time Big Byrd Creek was dammed to furnish power for a mill located near the southern end of the property, and the mill pond thus formed covered about 3 acres including the lower portions of Great Camp and Little Camp branches. The gravels covered by the old mill pond, which has since been drained, have never been worked. In

1897, a company, which held the property under lease and option, sank a number of prospect pits in the flat near the mouth of Great Camp Branch and started to work the deposits, but all work was discontinued when their nearly completed mill and cyanide plant were destroyed by fire. Where the prospect pits were sunk the gravel was found to be from 1 to 2½ feet thick and covered with an overburden of from 4 to 7 feet of sandy soil. It is stated that all the gravel carried gold, the values averaging from 1 to 2 pennyweight per square foot. The amount of gold did not seem to vary with the thickness of the gravel and most of it was found close to bedrock. The gold was quite coarse, many of the grains weighing from 0.10 to 0.20 pennyweight, while the largest nugget recovered weighed 1.78 pennyweight.

These facts prove that coarse gold was carried by the branches as far as the creek, and it can hardly be doubted that the gravels of the creek bed contain sufficient gold to make their mining profitable, providing a suitable method of handling them can be devised.

Any successful method of working these placer gravels will have to take into consideration the following facts:

(1) Along much of its course Byrd Creek is bordered by steep banks, which in places give way to high bluffs, and this would make its diversion difficult if not impracticable.

(2) The mean discharge of the stream is large and it is subject to occasional floods.

(3) There is not sufficient fall in the creek to allow the employment of sluices, and the disposal of tailings would be difficult.

(4) While no boulders occur in these gravels, the banks are in many places lined with trees, and their roots would probably interfere with dredging or similar methods of mining.

(5) At several points there are rapids in the creek caused by ledges of resistant rock which outcrop in the bed of the stream.

CHAPTER VIII.

DESCRIPTION OF COPPER MINES AND PROSPECTS.

TYPES OF COPPER DEPOSITS.

Copper ores have been prospected at three localities in this district and the ore-deposits consist of two distinct types. The Lightfoot mine on the southeast side of Slate River about 2 miles northwest of Arvonia, and the Anaconda mine, located 3½ miles west of Johnson and 5 miles north of Dillwyn, belong to one type, while the mines near New Canton are opened in a very different kind of ore-deposit.

Ores of the type first mentioned occur as veins or lenticular masses in greenstone schists derived from basic igneous rocks, while ores of the last-named type are found impregnating crystalline schists, adjacent to their contact with an intrusive granite (quartz-monzonite with a dioritic border facies). In both types the principal ore-minerals are pyrite, more or less auriferous, and chalcopyrite. The origin of the ores belonging to each type will be discussed after the individual occurrences have been described.

DESCRIPTION OF INDIVIDUAL MINES.

The Lightfoot Mine.

Location.—The Lightfoot copper mine is located on the southeast side of Slate River, 2 miles northwest of Arvonia.

History.—The property was first worked for gold (see p. 207), but the copper deposit was opened shortly before the war by a company which is said to have shipped 100 tons of the ore to a smelting house in Baltimore, where it brought $80 per ton.[a] The outbreak of the war in 1861 put a stop to work at the mine, and since that time while there have been some spasmodic attempts to develop the property (the last about 1904) little has come of them. A shaft has been sunk to a depth of 85 feet, the collar of the shaft being about 20 feet above the level of the nearby stream, and several short drives have been opened.

Country rock.—The Lightfoot mine is situated in an area of greenstone schists, which under the microscope are seen to be igneous in origin. The strike of the schistosity is northeast and southwest and the dip is steeply

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[a]Hamilton, J. R., The Natural Wealth of Virginia, *Harper's Magazine*, 1865, vol. xxxii, p. 41.

toward the northwest. The schists show little variation in texture or color, being usually dark green and fine-grained. Megascopically, chlorite and epidote with occasional eyes and stringers of quartz and calcite are the most prominent minerals; and when the powdered rock is tested with a magnet it is found to contain an abundance of fine-grained magnetite. In addition to these minerals, plagioclase feldspars, hornblende and some titanium minerals can usually be recognized under the microscope. These rocks are described in greater detail on pages 49-51. A little pyrite, often more or less cupriferous, and the secondary copper mineral—malachite—were found in the schist at several places within a mile or less of the mine. Where the rocks have been much fractured the openings are filled with quartz, epidote, calcite, or mixtures of these, forming irregular veinlets. In places magnetite appears to have undergone a similar concentration and may be picked up on the surface in pieces the size of hen's eggs or even larger.

Ore-deposit.—According to Credner, the vein was 4 to 5 feet wide near the surface, and consisted of iron oxide; below this capping, iron pyrites was encountered and continued for about 20 feet before chalcopyrite began to appear; and in the lower workings he found a coarse-grained mixture of iron and copper sulphides, which carried 11 per cent. copper.[a] The lower workings of the present opening are said to show an irregular vein, which in places consists of roughly parallel veinlets, ranging from several feet in width down to an inch or less, and the walls are rather sharply defined.

The waste rock found on the dump shows that the country rock in the immediate vicinity of the vein has been greatly crushed and fractured. Extensive epidotization has taken place along the fractures, and where openings had been formed they are usually filled with quartz containing crystals of epidote and sometimes considerable calcite. The veinlets formed in this way are usually 4 or 5 inches in width or less. In places vug-like openings occur lined with quartz and crystals of epidote. Pyrite and chalcopyrite are occasionally present in the wall rock as well as in the veinlets, and where these minerals have been long subjected to oxidation the green stain of malachite is usually prominent. All the rock contains more or less magnetite, and fine-grained masses of this mineral, weighing several pounds, were noted, in which the only impurities that could be detected megascopically, were a little quartz, epidote, and occasionally

[a]Credner, H., Report of Explorations on the Gold Fields of Virginia and North Carolina, Amer. Jour. Mng., 1869, vol. vii, p. 58.

chalcopyrite. A piece of the greenstone schist found on the dump contained a veinlet or segregated area of white feldspars, which were 0.5 to 1 cm. in diameter, and showed fine albite twinning. Chalcopyrite and magnetite were plentifully distributed between the feldspars, and in places along their cleavage planes, in a way that indicated a later origin for the ore minerals.

The best ore seen at the mine consisted essentially of a mixture of pyrite and chalcopyrite, but most of the ore found on the dump was composed chiefly of pyrite, slightly cupriferous, with a little quartz, chlorite, and epidote visible to the naked eye. Assays of the ore are said to show good values in gold, and Hamilton states that native copper was found in some of the ore, but this could not be confirmed.

The Bumpus Property.

At several other localities in this vicinity a little prospecting for copper has been carried on. The old Bumpus place lies northwest of the Lightfoot mine on the opposite side of Slate River, and here a 20-foot shaft was sunk at a point where much limonite and magnetite were found on the surface. The shaft was opened in soft chloritic slate, and no copper ore seems to have been found.

The Ford Property.

On the Ford property, about three-quarters of a mile southwest of the Lightfoot mine, a vein is said to have been discovered in 1835, which was rich in gold at the surface, but at a depth of 4 or 5 feet copper pyrite became so plentiful as to interfere with amalgamation, and the work was abandoned.[a] Later, a 60-foot shaft was sunk to strike the vein at another point, but a few lenticular quartz concretions containing copper pyrite seem to be all that was found. Credner mentions two small veins that were exposed by open cuts, the gangue being quartz, while iron and copper pyrite, and a little free-gold were present.[b]

The Anaconda Mine.

Location.—The Anaconda mine is located near Eldridge Mill, and is about 3½ miles west of Johnson and 5 miles north of Dillwyn, stations on the Buckingham Branch of the Chesapeake and Ohio Railway.

History.—The Anaconda mine was formerly known as the Eldridge mine, and about 1903 it was under development by the Q. Q. Copper Co.,

[a]Hamilton, J. R., Op. cit.
[b]Credner, H., Op. cit.

which sank a shaft to a depth of approximately 60 feet. About 1905 the United States Mineral Co. did a little development work, and in 1910 the shaft was again pumped out, but almost immediately allowed to refill with water. The shaft is now said to have a depth of nearly 75 feet, and near the bottom, a short drive extends in a northeast direction. While work was going on, 3,300 pounds of ore running 10¾ per cent. copper were shipped to the smelter at Norfolk.

Descriptive geology.—The ore-deposit lies in the same belt of greenstone schists in which the Lightfoot mine is located and the country rocks are, for the most part, similar to those already described. About 400 yards northeast of the mine several openings have been made exposing amphibole asbestos, some of the fiber being 7 or 8 inches in length, talc, and chloritic schists carrying needle-like crystals of actinolite. The rock found on the dump is practically the same as that at the Lightfoot mine. It is mostly a dark green, fine-grained chloritic schist, in which considerable epidote is present especially along fractures. A little calcite in small crystals is in places scattered through the rock mass, but no veinlets or large masses were seen. Fine-grained magnetite and occasional grains of pyrite and chalcopyrite were noted. In a thin section (Spec. 352) the minerals present, in the order of their relative abundance, are quartz, chlorite, epidote and zoisite, hornblende, calcite, plagioclase feldspar, pyrite, and titanite. The hornblende occurs in dark green, needle-like prisms largely altered to chlorite. The calcite frequently shows multiple twinning. It is apparently a basic igneous rock which has been extensively altered by pressure and hydrometamorphism.

Specimens of the ore seen at the mine consist essentially of pyrite and chalcopyrite intercrystallized with quartz as gangue. A little bornite, probably secondary, was noted in places, and the carbonates azurite and malachite, derived from the sulphides, are also present, usually along fractures in the rock. The vein is said to be several feet wide in places, but elsewhere pinches to almost nothing.

Genesis of Ores at the Lightfoot and Anaconda Mines.

Many basic igneous rocks in different parts of the world have been found to contain small quantities of copper. Rocks of this type are common throughout much of the Blue Ridge region in Maryland and Virginia where there are basaltic lava flows, which, since their extrusion, have been greatly altered, with the production of secondary minerals, especially chlorite and epidote. As a result of the metamorphic changes

which these rocks have undergone, the small amount of copper originally disseminated in the rock has, in places, been locally concentrated along joints and fractures, giving rise to copper deposits which have become known as the Blue Ridge or Catoctin type.[a]

The ores at the Lightfoot and Anaconda mines are similarly situated in an area of altered basic rocks, igneous in origin; and copper-bearing minerals have been found occurring in the country rock in small quantities at a number of widely separated localities; but there is a marked difference between the ore-deposits in this area and those of the Blue Ridge type, especially in the character of the ore-minerals. In the Blue Ridge type of deposit, the ore-minerals are chiefly cuprite and native copper, the latter often as nucleal masses surrounded by cuprite, together with small amounts of azurite and malachite, and, very rarely, of copper sulphide.[b] At the Buckingham County mines the copper minerals are chiefly sulphides, malachite and azurite being present only to a limited extent, and where they have been clearly derived from the sulphides, while cuprite and native copper are rare if they occur at all.

Both the Lightfoot and the Anaconda mines were inaccessible when the writer visited the district in 1910, and it would be impossible to make definite statements in regard to the genesis of the ore-deposits without more detailed examination, but it seems probable that the copper, which they contain, was originally disseminated through the surrounding rocks, and that it has been concentrated by the circulation of meteoric waters, at favorable points in openings formed by local fracturing. Some of the principal facts in favor of this hypothesis may be summed up as follows:

(1) Copper-bearing minerals are present in small quantities in the country rock at considerable distances from the ore-deposits, and therefore the country rock furnishes a possible if not the probable source of the ore-minerals.

(2) The principal gangue minerals in the ore-deposits—quartz, epidote, calcite, and magnetite—are important constituents of the country rock, the difference being one of relative proportions only, and no minerals have been observed in the ores that have not been found in the country rock. Therefore the country rock furnishes a possible if not the probable source of the gangue minerals.

[a]Weed, W. H., Types of Copper Deposits in the Southern United States, Trans. Amer. Inst. Min. Eng., 1900, vol. xxx, p. 498.

[b]Weed, W. H., Copper Deposits of the Appalachian States, U. S. Geol. Survey, Bull. No. 455, p. 14.

(3) The fracturing of the rocks furnished a channel for the circulation of concentrating solutions and openings for the deposition of the ore-deposits.

(4) The extensive formation of hydrous from anhydrous minerals, which is the chief feature in the metamorphism of the great mass of rocks in this immediate area, necessitates the introduction of much water, and circulating water is an agent sufficient to account for the transportation and concentration of the minerals forming the ore-deposits.

(5) The extensive formation of epidote adjacent to fractures in the immediate vicinity of the ore-deposits is evidence of the circulation of solutions at these points.

The difference between the Buckingham copper deposits and those of the Blue Ridge type may possibly be due to the formation of the former at a greater depth, and to the fact that the greenstone schists in this district are, as a whole, more dense, closer textured and without the amygdaloidal cavities and similar openings common in much of the Catoctin schist. As originally deposited, these ores probably consisted chiefly of cupriferous pyrite, and in that case most of the chalcopyrite owes its origin to secondary enrichment. It is doubtful whether the copper values will continue to any considerable depth from the surface, and the writer does not believe that these deposits will prove to be very extensive or of much economic value.

THE NEW CANTON MINES.

The New Canton ore-body has been exposed by a series of openings, consisting chiefly of shafts and tunnels, which begin at a point half a mile south of New Canton and extend in a straight line for a distance of a mile in a southwesterly direction. (See map, fig. 2, p. 17.)

HISTORY.

While the New Canton mines have never been of much economic importance, they have had a long and varied history, having been first worked for iron, later for copper, and more recently prospected for pyrite. The gossan or oxidized ore, which consists principally of limonite and forms the surface cap of the sulphide bodies, first attracted attention; and according to Prof. Rogers, iron was manufactured from the Buckingham ore as early as the Revolutionary War. However, very little mining was done until some time in the early 30's, when a charcoal furnace, known as the Bear Garden or Dean furnace, was built about half a mile south of New Canton. In his "Report of the Geological Reconnoissance of the

State of Virginia, 1835," Rogers states that, "the limestone on the western edge of the county furnishes the flux employed in the smelting of this ore, which, under the superintendence of Mr. Dean of New Canton, is now conducted on a scale of such extent as to give a weekly product of between thirty and forty tons of pig metal, much of which is of a superior quality."[a] Piles of slag indicate that there was another furnace located less than a mile southwest of New Canton. Mining was entirely confined to surface cuts along the outcrop, and as these became deeper pyrite began to appear and rapidly increased until the percentage of sulphur became prohibitive. Rogers says that fine specks of gold were discovered in the cinder or slag at these works. Iron ore was also hauled from Ore Bank, three-quarters of a mile southeast of Arvonia, and smelted at the New Canton furnace, but in 1840 the furnace was abandoned and no further work seems to have been done until prospecting for copper was started.

The Johnson Mine.

At the Johnson mine, formerly known as the Staples mine, which is located three-quarters of a mile west of south from New Canton, a 78-foot shaft was sunk by Mr. Staples, who mined and shipped 780 tons of ore averaging 8 per cent. copper. After this the property was leased and operated by White & Walters for a period of 2 or 3 years, beginning about 1891. Several shipments were made and $4,000 is said to have been realized from the copper in the ore. About 1903, the Johnson Mining Co. bought the property and began development work. A vertical shaft, started on top of the hill, was sunk to a depth of 278 feet, and an adit was driven from the creek northwest to connect with the shaft. There are 3 levels in the mine and the total length of the drives is said to be 1,000 feet or more, but little or no mining was done.

The McKenna Mine.

The McKenna mine joins the Johnson mine on the northeast, and is situated a little over half a mile south of New Canton. It was first prospected for copper by J. P. McKenna about 1895, and in 1906 the Virginia Copper Co. began to develop the property. A 53-foot shaft was sunk at the foot of the hill in the lowlands near the creek, and two short drives opened from it, but work was stopped in 1907, and has not been resumed since that time.

[a]Rogers, W. B., Geology of the Virginias, p. 80.

The Hudgins Mine.

The Hudgins mine, located 1.5 miles southwest of New Canton, was opened about the same time that the other two mines were being prospected. A shaft was sunk to a depth of about 70 feet, which seems to have been the extent of the development work. When visited by the writer in 1911 the shaft had partly caved and was inaccessible.

The Margaret Mine.

The Margaret or Terrell mine adjoins the McKenna mine and is situated on the west side of Phelps Creek about half a mile south of New Canton. This property was first opened in April of 1910, when a shaft was sunk to a depth of 80 or 90 feet in search of a pyrite deposit that could be profitably worked. When examined by the writer in the summer of 1911 the shaft had been pumped out, and preparations were being made to sink it deeper.

GENERAL DESCRIPTION OF THE GEOLOGY.

The bluffs along James River and Phelps Creek furnish an almost perfect section across the rock strata in which the New Canton mines are situated, and this section, together with the mine openings and occasional outcrops elsewhere in the vicinity, make it possible to study these ore-deposits in somewhat greater detail than can be done in the case of most of the veins that occur in this area.

The New Canton sulphide deposits occur in a schist, sedimentary in origin, which, a few hundred yards west of the mines, is interbedded with a schistose quartzite. East of the mines, stretches the area of intrusive granite (chiefly granodiorite), but between the granite and the ore-deposits is a belt of hornblendic schists 700 to 900 yards wide, part of which represents a basic border facies of the granite, while the rest is probably sedimentary in origin, though intensely metamorphosed by the intrusion of the great igneous magma. It is not possible to draw with certainty a line between the hornblende schists that are igneous, and those that are chiefly sedimentary in origin, for the former as well as the latter have been greatly changed by metamorphism under mass-mechanical conditions; and the difficulty is increased by the fact that there are dikes or apophyses from the igneous mass, interleaved with metamorphic rocks which are apparently sedimentary in origin. The series of rocks encountered in passing across this contact is described in detail on pages 107-112, and therefore they will be discussed here only in so far as it is necessary to bring out their relations to the ore-deposits.

Northeast of the mines, at a distance of 300 to 400 yards, the country rock is a dark gray knotted slate, or schist, containing numerous rounded pseudophenocrysts of biotite averaging 1 to 1.5 mm. in diameter. These crystals of biotite are dark brown to black in color and have no regular orientation relative to the schistosity of the fine-grained slaty ground-mass in which they are embedded. Small reddish-brown garnets may also be present but are not plentiful. In the ground-mass quartz, sericite, and a few scattered grains of magnetite, are the only minerals distinguishable megascopically, but under the microscope biotite, chlorite, and rarely plagioclase feldspar, may also be identified.

Passing eastward toward the contact, the biotite crystals gradually give place to garnets, and at the same time the schists become slightly coarser grained and lighter in color. The difference in color may be due to difference in composition, but is probably, in part, caused by increased development of sericite and a greater concentration of the iron in certain iron-bearing minerals. Small crystals of pyrite are abundant in the schists near the ore-bodies, which have no definite walls or boundaries. The ore is found in white to light gray, garnetiferous schists which, aside from the impregnating pyrite, are composed essentially of sericite and quartz, though chlorite is usually present and sometimes in considerable quantity. Plagioclase feldspar occurs to a limited extent, and occasional crystals of hornblende begin to make their appearance.

The ore-minerals, chiefly pyrite, occur irregularly disseminated through the quartz-sericite schist, and where most abundant form irregular stringers or lenses parallel to the schistosity. The mineralized schists are cut by occasional small lenticular veins of quartz, carrying more or less feldspar, but as a rule they contain little pyrite, though the latter, in places, is concentrated along the walls of the veins.

The hornblende schists on the east side of the ore-bodies are usually fine-grained but vary somewhat in composition and texture in passing across their strike. In the vicinity of the ore-deposits, and for some distance along their line of strike where they have not been found, there is usually much pyrite in the hornblende schists. Within 100 or 150 yards of the ore-bearing schists, apophyses of the granite occur as intrusions in the hornblendic rocks, and, at least in places, there is a narrow band along their contacts composed essentially of chlorite and garnets. The line drawn on the map (fig. 2) to represent the approximate contact between the rocks that are igneous and those that are sedimentary in origin, is located on the basis of the structural relations and appearance of the rocks

in the field, rather than on any difference in texture or mineral composition, and while it is unlikely that there are important masses of altered sedimentary rocks on the east side of the line, there are known to be apophyses or dikes on the west of it. Much vein quartz occurs as small pieces in the soil derived from the sedimentary schists in the vicinity of their contact with the area of igneous rocks on the east.

The ore-body is apparently continuous for a distance of more than a mile along its course. It is not exposed in the section furnished by the bluffs along Phelps Creek, although near the line of its strike much pyrite is present in the schists. Southwest of the Hudgins mine, outcrops are not as plentiful, and it is impossible to say how much farther the ore-body extends in that direction. A little prospecting is reported at several places, but nothing of value has been discovered.

DETAILED DESCRIPTION OF THE ORE AND INCLOSING ROCK.

The Margaret Mine.

The outcrops of the ore-bearing rocks are stained with limonite and more or less porous from the oxidation of sulphides. In places directly above the ore-body there are large outcrops of gossan, consisting of dark brown, porous limonite containing comparatively little silica, and only occasional fragments of decomposed schist. At the Margaret mine, the dark bluish-gray schist with phenocrysts of garnet and biotite occur less than 100 feet west of the shaft started in the limonite capping, and pieces of hornblende schist were found lying on the surface only a short distance toward the east. Intermingled with the hornblende schist were found a few pieces of fine-grained quartzite, carrying irregular dark green crystals of hornblende and light greenish-brown needles of sillimanite. Pieces of rock were also found which appear to be intermediate in mineral composition between the hornblende schists and the quartz-sericite-chlorite schists.

The shaft at the Margaret mine was sunk on top of a ridge about 30 to 40 feet above the creek and the limonite ores continued to a depth of 28 or 30 feet, which is approximately the water level, before pyrite was encountered. Pyrite more or less cupriferous is the chief ore-mineral from this point down, but at a depth of about 55 feet it is accompanied by some chalcopyrite and bornite. The copper sulphides are not very plentiful and seem to be confined to a zone having a vertical thickness of 4 or 5 feet. In the bottom of the shaft which is about 90 feet deep, pyrite, slightly cupriferous, is the only ore-mineral. Fractures or joints in the rocks are frequently coated with hyalite, usually white but some-

times light green from copper stain. The strike of the schistosity is about N. 30° E. and the dip practically vertical. All the schists exposed in the shaft are more or less impregnated with sulphides, but the distribution is very irregular, the areas of greatest concentration frequently having the appearance of veinlets of pyrite. The schists are cut by occasional small lenticular veins of quartz and feldspar ranging up to 5 or 6 inches in width. The sketch shown in fig. 23 roughly illustrates the structural relations of the ore-deposit and the distribution of the pyrite.

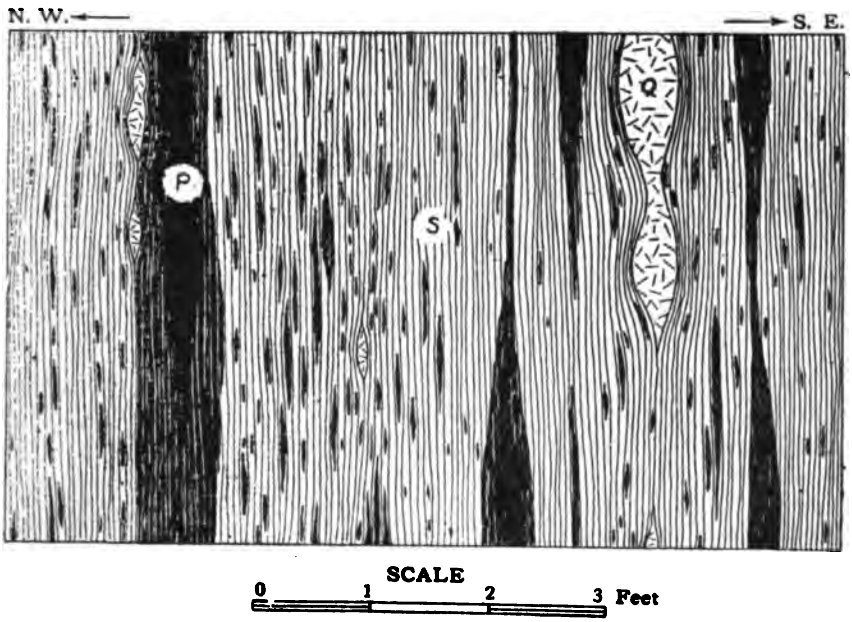

Fig. 23.—Diagrammatic section showing quartz-feldspar lenses and distribution of sulphides in schist at the Margaret Mine. *Q*, quartz-feldspar lens; *S*, schist with a little disseminated pyrite; *P*, chiefly pyrite.

The richest ore consists of 80 or 90 per cent. pyrite, a little white sericite, scattered pink garnets 1 to 1.5 mm. in diameter, a few small flakes of chlorite, and a little quartz. A thin section for microscopic examination was made from a piece of schist (Spec. 312-C) carrying about 60 per cent. pyrite. In the hand specimens the rock appears to consist almost wholly of slightly cupriferous granular pyrite (1.5 to 2 mm. in diameter) and white sericite, with only a few small pink garnets. The distribution of the sulphides is closely related to the schistosity of the rock.

Near joint planes the sulphides have a dark coating and the white sericite is stained green by the presence of a small amount of copper. Under the microscope the smaller crystals of pyrite frequently show cubical form, but the larger masses have irregular outlines. The sericite is mostly oriented parallel to the schistosity, but many of the flakes look as though they had been pushed aside by the pyrite. Quartz is more plentiful in the thin section than one would suppose from a megascopic examination of the rock. It shows marked optical distortion and slight granulation from crushing, and contains occasional liquid and gaseous inclusions. A little magnetite is present in small grains and is usually closely associated with pyrite.

Another specimen (316) of schist, showing the contact with a quartz-feldspar stringer which cuts across the cleavage and has narrow veinlets of quartz branching off parallel to the schistosity, is a light gray, close-textured rock composed of fine-grained quartz, sericite, chlorite, a little magnetite, and numerous red garnets ranging up to 1 mm. in diameter. Pyrite is plentiful but not abundant, occurring in grains and small lenticular masses elongated in the direction of schistosity; and while disseminated throughout the rock appears to be slightly more concentrated near the quartz veinlets. Under the microscope the quartz grains show irregular interpenetrating outlines and wavy extinction. The flakes of sericite and most of the light green chlorite are oriented parallel to the schistosity. The garnets are very ragged in outline and micropoikilitic in texture from numerous inclusions of quartz. In places they show slight alteration to chlorite. Plagioclase feldspars are also present and the minerals magnetite and pyrite are plentiful, frequently showing a close association, with pyrite occurring as inclusions in the magnetite or with the latter surrounded by the former.

The quartz-feldspar veinlets range up to 6 inches or more in width, and are composed essentially of coarsely crystalline quartz, varying from white and translucent to clear and glassy, with more or less feldspar in angular crystals, having sharp straight outlines, ranging up to 1 cm. or over in diameter, and white to light yellow in color. In portions of the veinlets feldspar constitutes 10 per cent. or more of the mass while elsewhere it is practically absent. The feldspar crystals occur throughout the vein but are more plentiful near the walls and in places extend for a fraction of 1 cm. into the enclosing schists. Small masses of chlorite and garnet, probably representing inclusions of the country rock, are occasionally present. A little pyrite occurs in the central portions of the veinlets,

usually along cleavage planes or contacts between feldspar and quartz, but most of it is found near the walls and is yet more abundant in the enclosing schists. In thin section (315) under the microscope, the quartz shows some granulation and marked undulatory extinction, but the feldspars, aside from a slight warping of the cleavage planes, which is visible in the hand specimen, show no pressure effects. The feldspar is a soda-lime plagioclase, chiefly oligoclase-andesine, and usually shows multiple twinning after the albite law, though this appears to be absent in places.[a] Liquid and gas inclusions, usually arranged in rows or planes, are plentiful in the quartz and occur to a lesser extent in the feldspar.

The McKenna Mine.

At the McKenna mine the gossan is exposed in the side of the hill just above the shaft, and apparently grades into the enclosing schists. It is said to be only about 8 feet deep in the shaft, which is located not far from the creek and fills with water almost to the surface. Descriptions of the ore-body exposed by the underground workings, and the rock lying on the dump, indicate that the deposit is similar in every way to that at the Margaret mine. It is reported that "peacock" copper ore was struck in the shaft about 35 feet from the surface, where it was about 8 feet wide and 6 feet thick. The walls of this secondary copper deposit were fairly well defined, but the large masses of pyrite graded into the country rock without definite walls.

A specimen obtained by Dr. Maynard from the bottom of the shaft, 53 feet from the surface, is darker colored and more chloritic than most of the rock found on the dump or in this vicinity. It is a dark green foliated schist in which chlorite, quartz, biotite, garnet, pyrite, and magnetite are easily distinguished megascopically. In thin section (Spec. 6) plagioclase feldspars can be identified, but as they closely resemble the quartz in index of refraction and do not always show twinning, it is impossible to estimate their relative abundance, though the quartz is probably much in excess. Part of the chlorite gives evidence of its derivation from biotite. A little sericite is also to be seen and a few light brown prismatic crystals, probably of hornblende. Pyrite is abundant and magnetite plentiful, the two minerals being closely associated, with pyrite usually surrounding the magnetite.

[a]A specimen of this feldspar was submitted to Dr. E. S. Larsen, Jr., for determination by the immersion method. He identified the feldspars as albite-oligoclase to oligoclase-andesine and states that the fresh and dominant feldspar is oligoclase-andesine. The maximum and minimum indices of refraction are:

$$\alpha = 1.535 \pm 0.003 \text{ to } 1.541 \pm 0.003$$
$$\gamma = 1.542 \pm 0.003 \text{ to } 1.549 \pm 0.003$$

Some of the rock on the dump contains a little hornblende and probably represents the first stage of the gradation into hornblende schist. It is a light gray schist (Spec. 34) with a greenish tinge, consisting of fine-grained quartz, chlorite, sericite, garnets about 1 mm. in diameter, small grains of magnetite, and much disseminated pyrite, which is partly arranged in irregular planes parallel to the schistosity. The hornblende which is not plentiful occurs in dark green crystals ranging up to 2 or 3 mm. in diameter. Examined under the microscope, the smaller garnets have well-defined outlines but the larger ones are usually ragged, and all of them contain included grains of quartz. The magnetite is disseminated in grains and small angular masses showing more or less distinct crystal outline. Pyrite is frequently in contact with magnetite and often occurs in narrow planes or lenses parallel to the schistosity. Small plagioclase feldspars and dark green prismatic crystals of hornblende, with a few grains of titanite, and small inclusions of apatite and zircon, make up the minor accessories.

About 50 yards southeast of the McKenna shaft, a small diabase dike outcrops, but could not be traced any distance. The strike is probably northeast and southwest. It is a medium-grained, dark gray rock with ophitic texture easily recognizable in the hand specimen, and twinning can be seen on the feldspars with the aid of a pocket lens. Pieces of rock found on the dump indicate that a very fine-grained diabase dike, which in places is only 1½ inches wide, was encountered in the underground workings.

The Johnson Mine.

At the Johnson mine, the gossan may be seen outcropping in the road 100 yards south of the shaft, and there is much vein quartz lying on the surface in the same vicinity. A short distance north, there are outcrops of the same knotted schist found on the east side of the ore-body wherever there are exposures. This rock was also encountered in the underground workings, and a thin section was made from a piece of the schist (Spec. 319-A) found on the shaft dump. It is a dark gray, thinly foliated schist with the folia wrinkled by numerous small pseudophenocrysts of garnet and biotite around which they are folded. The garnets are much more plentiful than the biotite crystals, and there is also a little pyrite. Under the microscope the biotite crystals are seen to contain numerous included grains of quartz and in a few instances the flakes are bent or curved, giving the mineral an undulatory extinction. They have no uniform orientation. The ground-mass is composed essentially of quartz and sericite with a little

chlorite, biotite, and very rarely plagioclase feldspar. The quartz occurs in elongated grains interleaved with fine shreds of sericite, all being perfectly oriented parallel to their greatest dimension. Flakes of sericite in the same vicinity extinguish together except where the folia are bent around the pseudophenocrysts, and there they look as though they had been pushed aside by the mineral in its growth, forming lenticular eyes, with quartz usually filling the ends of the lenses. Some of the eyes contain two crystals instead of one, though this is not common. A similar rock (Spec. 307) in which the eyes are formed chiefly of biotite instead of garnet, is found at a somewhat greater distance from the granite. It is described on pages 32-33.

Hornblende schist outcrops in the road less than 100 feet south of the gossan, and a microscopic slide (Spec. 458) was made from some of the rock obtained within 200 feet. In the hand specimen it is a fine-grained, dark green rock, close-textured and slightly schistose, composed for the most part of hornblende, quartz, and chlorite. Under the microscope the rock is distinctly schistose because of the approximate orientation of the hornblende. This mineral is dark green in color, ragged in outline, and only occasionally contains inclusions of the other minerals. The hornblende constitutes about 75 per cent. of the rock mass. Irregular grains of quartz, chlorite, partly if not wholly derived from hornblende, a little plagioclase feldspar, and a few grains of magnetite make up the remaining constituents. In the absence of chemical analyses it is impossible to say whether this rock is igneous or sedimentary in origin, but the manner in which it is interbedded with other schists varying slightly in composition, leads the writer to believe that this schist is more likely derived from a sedimentary rock.

At the mouth of the adit about 150 feet southeast of the Johnson shaft, a fine-grained, dark gray schist is exposed, in which quartz, chlorite, probably hornblende, magnetite, and pyrite are the only minerals coarse enough for megascopic identification. A thin section (Spec. 319-B) was made from a similar rock found on the dump. In the hand specimen it is a fine-grained, compact rock, gray with a slightly greenish tinge. It is slightly banded and contains a little disseminated pyrite, but most of the minerals are too small for megascopic identification. Under the microscope it is seen to consist of quartz, hornblende, soda-lime feldspar, chlorite, and magnetite, the order given being that of relative abundance. The quartz occurs in clear grains showing no granulation and little optical distortion. Hornblende is present in ragged individuals with numerous

inclusions of quartz and magnetite, and varies in size up to nearly 1 mm. in length. The crystals are uniformly oriented parallel to the schistosity. Plagioclase feldspar (probably andesine) is plentiful, and usually shows albite twinning. The chlorite is light green in color and occasionally shows multiple twinning. Magnetite occurs in small irregular grains uniformly distributed throughout the slide.

Another variety of hornblende schist found on the dump is coarser grained (Spec. 320-A). Megascopically it is a dark green schistose rock containing crystals of green hornblende 1 to 2 mm. in diameter, brown biotite, green chlorite, and occasional brown garnets. In thin section the hornblende is light green in color, very ragged in outline, and contains numerous inclusions of the other minerals, principally quartz. It shows extensive alteration to carbonate and chlorite. The biotite has strong absorption, changing from brown to pale brown or colorless, and in places it shows alteration to chlorite. Quartz and soda-lime feldspar (andesine) are present in small grains, partly as inclusions in the hornblende and partly filling interstitial spaces. The feldspars usually show albite twinning. Grains of titanite, magnetite, and occasional rutile needles make up the minor accessories.

Descriptions of the ore-body by men who worked in the mine, and the material found on the dumps, indicate that the ore-deposits at the Johnson mine are essentially the same as at the mines previously described. The ore-body is said to dip toward the northwest at an angle of about 80°. In some of the ore found on the dump pyrite occurs mixed with pyrrhotite and a little chalcopyrite, the gangue minerals being a small amount of quartz and sericite. Fragments from quartz-feldspar veinlets are also present on the dumps. The copper ore that was mined and shipped from this property is said to have consisted chiefly of "rich black copper ore" (chalcocite) found a short distance below the water level, and little or no high-grade copper ore seems to have been found in the lower workings.

The Hudgins Mine.

The country rock at the Hudgins mine, as indicated by outcrops in the vicinity, is exactly the same as at the other mines described above, and there seems to be no essential difference in the character of the ore-deposit. The material found on the dump is not as heavily impregnated with sulphides as at the Johnson and McKenna mines, and most of the ore-bearing schist is much lighter colored. Some of the rock closely resembles the quartz-sericite schist at the London and Virginia and Buckingham

mines. It is a fine-grained, white, lustrous schist in which quartz, sericite, and disseminated pyrite are the only minerals that can be identified with a pocket lens. Other pieces found on the dump are similar but contain a few scattered flakes of biotite.

GENESIS OF THE NEW CANTON ORE DEPOSITS.

The New Canton ores belong to that class of ore-deposits known as contact deposits, and it is believed that the sulphides which occur impregnating the schists near the contact were derived from the mass of intruded igneous rock that lies to the east. Acid igneous rocks on cooling give off a large amount of water in the form of highly heated vapor or gas, and this water may carry minerals in solution and deposit them where the conditions are most favorable. That this has been the mode of formation of the New Canton deposits is indicated by the facts, brought out in the detailed descriptions, which may be summarized as follows:

1. The location of the ores in highly metamorphic schists close to their contact with an acid igneous intrusive.
2. The extensive alteration of the ore-bearing schists with the production of sericite, chlorite, and garnet.
3. The presence of lenses and veinlets of quartz and feldspar, which in places approach pegmatite in composition and appearance.
4. The association of pyrite, chalcopyrite, pyrrhotite, and magnetite as the principal ore minerals.

As has been stated elsewhere in this report, the intrusion of the granite (granodiorite) was accompanied by a partial segregation or concentration of the more basic minerals in the border portions of the cooling magma, and the extensive metamorphism of the sedimentary rock along the contact. The rocks nearest the granite possibly owe their alteration, which resulted in the production of hornblendic rocks, chiefly to heat and pressure, but the alteration of the schists at a somewhat greater distance from the contact, seems to have been due primarily to the heated vapors expelled from the cooling magma. This is indicated by the predominance of the anhydrous minerals, chiefly hornblende, in the rocks nearest the contact; while in the ore-bearing schists, such hydrous minerals as sericite and chlorite were extensively developed. The occurrence of masses of chlorite containing many large garnets, which even under the microscope show no alteration, is difficult to account for if the chlorite was formed entirely as a result of superficial agencies, and, moreover, the inclusions of country rock found in the quartz-feldspar veinlets are all altered to chlorite, biotite,

and garnet. The same solutions that altered the schists and formed the quartz-feldspar veinlets, deposited the sulphide ores, chiefly pyrite. Some chalcopyrite may have been deposited as a primary mineral at this time, but it seems probable that most if not all of the copper was originally deposited as cupriferous pyrite. The sulphides undoubtedly filled any openings that may have been present, and while the schist may have been injected with veinlets and stringers of pyrite, as with quartz and feldspar, most of the sulphide masses, even where purest, give evidence of formation through metasomatic replacement of the schist.

The frequent association of pyrite and magnetite suggests that the latter was formed by the reducing action of pyrite, since siderite is a prominent constituent in some of the knotted slates a few hundred yards west of the contact. Van Hise has called attention to the development of magnetite from iron carbonate on an extensive scale where igneous rocks have been intruded into ferruginous sedimentaries, and gives the following chemical equation as the probable reaction by which the magnetite is produced:[a]

$$2FeCO_3 + FeS_2 + 2H_2O = Fe_3O_4 + 2H_2S + 2CO_2$$

The hydrogen sulphide set free by the reaction would aid in the alteration of the schists by combining with the iron derived from the iron-bearing silicates, and it is not improbable that the light color of the ore-bearing schists is partly due to the formation of pyrite at the expense of the dark-colored, iron-bearing silicates.

The primary ore consisting chiefly of pyrite, slightly cupriferous, with perhaps more or less chalcopyrite, had a very low copper content. The high-grade copper ore, such as that obtained at the Johnson mine a short distance below water level, owed its formation to concentration through meteoric agencies, of the copper originally present in the upper portion of the ore-body. Surface waters, entering the ore-body by means of small pores, cracks, and joints, carry oxygen and carbon dioxide in solution which react on the sulphides to form copper sulphate and other more or less soluble salts. The copper salts, being more soluble than the iron compounds formed, are mostly leached out and carried farther down, where the copper is reprecipitated by replacing iron in the fresh sulphides below. As a result of these reactions, oxides and carbonates of copper may be present in the upper, oxidized portion of the ore-body, while the rich sulphurets, such as chalcocite, bornite, and chalcopyrite, occur near the

[a]Van Hise, C. R., A Treatise on Metamorphism, Monograph XLVII, U. S. Geol. Survey, 1904, p. 838.

water level, and in the deeper portions of the ore-body only the low-grade, primary sulphides are found.

The practical absence of malachite, azurite, and copper oxide from the oxidized portion of these ore-deposits is probably due to the low copper content of the primary ores, the humid climate, and the long period during which the copper has been subjected to concentration. The ore-bodies originally extended much higher above the present surface, and part of the copper contained in the zone of secondary enrichment undoubtedly came from the upward extension of the deposits, which have been removed by erosion during the long period of time which has elapsed since the ores were first formed.

COMPARISON WITH OTHER ORES OF THE DISTRICT.

There is a marked resemblance between the New Canton ores and those at the London and Virginia, and Buckingham mines, the difference being chiefly in the relative proportion of the minerals present. At the latter locality the sulphides, which are apparently not as plentiful, occur chiefly as impregnations in a quartzite instead of a schist, the quartz-feldspar veinlets are more prominent, and the gold content is greater while that of copper is less. The New Canton type of deposit seems to represent one extreme of a gradational series, the typical gold-bearing veins of the district being at the other extreme, with the London and Virginia type intermediate between the two. At the New Canton mines the secondary ores were, in places, rich enough in copper to pay for their extraction, but these ores can not be expected to extend any great distance below the water level, and it is not believed that the copper content of the primary ores is sufficient to make them of value as a source of that metal. While in places high-grade pyrite occurs in the deposits, the greater portion of the ore-body contains a large amount of gangue material, and it is improbable that these mines could be profitably worked at the present time for their sulphur content alone.

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The Virginias.

INDEX

VIRGINIA GEOLOGICAL SURVEY

UNIVERSITY OF VIRGINIA

THOMAS LEONARD WATSON, PH. D.

DIRECTOR

Bulletin No. VIII

Biennial Report

ON THE

Mineral Production of Virginia

During the Calendar Years

1911 and 1912

BY

THOMAS L. WATSON

WITH CHAPTERS ON

Zirconiferous Sandstone Near Ashland, Virginia

BY

THOMAS L. WATSON AND FRANK L. HESS

AND

Geology of the Salt and Gypsum Deposits of Southwestern Virginia

BY

GEORGE W. STOSE

CHARLOTTESVILLE
UNIVERSITY OF VIRGINIA
1913

J.P. BELL COMPANY
INCORPORATED
Printers
Designers
& Engravers
Lynchburg, Va.

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General Manager of the C. & O. Railway.

THOMAS LEONARD WATSON,
Director of the Survey.

CONTENTS

ILLUSTRATIONS

LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, October 15, 1913.

To His Excellency, Hon. Wm. Hodges Mann, Governor of Virginia, and Chairman of the State Geological Commission:

SIR:—I have the honor to transmit herewith for publication, as Bulletin No. VIII of the Virginia Geological Survey Series of Reports, a Biennial Report on the Mineral Production of Virginia during the Calendar Years 1911 and 1912, by Thomas L. Watson, with chapters on "Zirconiferous Sandstone Near Ashland, Virginia," by Thomas L. Watson and Frank L. Hess, and "Geology of the Salt and Gypsum Deposits of Southwestern Virginia," by George W. Stose.

Respectfully submitted,
THOMAS L. WATSON,
Director.

BIENNIAL REPORT ON THE MINERAL PRODUCTION OF VIRGINIA DURING THE CALENDAR YEARS 1911 AND 1912

BY THOMAS L. WATSON.

INTRODUCTION

This bulletin includes (1) a discussion of the mineral production of Virginia for the calendar years 1911 and 1912, (2) a description of the occurrence of zirconiferous sandstone near Ashland, and (3) a summary of the geology of the salt and gypsum deposits of southwest Virginia. The description of surface features of the State, given in Bulletins I-A and VI of the Survey, has been omitted in this report.

The statistics of mineral production in Virginia for the calendar years 1911 and 1912 were collected by the Virginia Geological Survey in coöperation with the United States Geological Survey. The total number of productive operations for the two years was large and included a variety of subjects, as indicated in the totals below of annual production.

The total value of the mineral industry in 1911 amounted to $19,320,970, and in 1912, $21,276,157, distributed as shown in the table on page 2.

With but few exceptions the returns indicate substantial gains in the products mined and quarried in the State. The total aggregate value of the mineral industry in 1912 showed an increase of $1,955,187 over that of 1911. The most noticeable increase was that of coal, and the most marked decrease was in iron ores.

The mineral products mined and quarried in Virginia in 1911 and 1912 are discussed in this report in the following order: Iron ores, manganese ores, gold and silver, copper, lead and zinc, tin, coal and coke, clay and clay products, lime and cement, sand and gravel, stone (granite, limestone, sandstone, slate, crushed stone, and furnace flux), abrasives (millstones), silica (diatomaceous earth), mica, feldspar, asbestos, talc and soapstone, bartyes, gypsum, salt, mineral paints, marl, pyrite and pyrrhotite, arsenic, rutile, and mineral waters.

Mineral Production of Virginia in 1911.

Product	Unit of Measurement	Quantity	Value
Clay products			$ 1,743,007
Coal	Short tons	6,864,667	6,254,804
Coke	Short tons	910,411	1,615,609
Copper	Pounds	90,000	11,250
Gold	Fine ounces (Troy)	148	3,064
Granite			420,611
Iron ores	Long tons	610,871	1,146,188
Iron, pig	Long tons	308,789	3,898,285
Lead	Short tons	415	37,374
Lime	Short tons	132,133	483,016
Limestone			369,872
Manganese ores	Long tons	2,455	24,546
Millstones			17,635
Mineral waters	Gallons	2,474,918	298,701
Pyrite	Long tons	150,800	558,494
Sand and gravel	Short tons	553,996	204,170
Sandstone			31,315
Silver	Fine ounces (Troy)	21	11
Slate	Squares	40,040	188,808
Talc and soapstone	Short tons	26,759	660,926
Zinc (spelter)	Short tons	1,032	117,695
Other products[a]			1,235,589
Total			$19,320,970

[a]Includes asbestos, bartyes, cement (Portland), feldspar, ferro-alloys, gypsum, diatomaceous earth, manganiferous ore, metallic paints, mica, ocher, and salt.

Mineral Production of Virginia in 1912.

Product	Unit of Measurement	Quantity	Value
Clay products			$ 1,884,743
Coal	Short tons	7,846,638	7,518,576
Coke	Short tons	967,947	1,815,975
Granite			470,657
Iron ores	Long tons	412,520	903,130
Iron, pig	Long tons	328,961	4,364,708
Lime	Short tons	124,711	488,628
Limestone			403,063
Manganese ore	Long tons	1,537	14,881
Metals (gold, silver, copper, lead, and zinc)			74,855
Millstones			25,866
Mineral waters	Gallons	2,762,319	349,255
Pyrite	Long tons	162,478	621,219
Sandstone			4,020
Sand and gravel	Short tons	689,266	291,773
Slate	Squares	42,220	195,392
Talc and soapstone	Short tons	25,313	576,473
Other products[a]			1,272,943
Total			$21,276,157

[a]Includes barytes, briquets (fuel), Portland cement, feldspar, ferro-alloys, gems and precious stones, gypsum, diatomaceous earth, manganiferous ore, ocher, metallic paint, rutile, and salt.

IRON ORES AND PIG IRON.

The production of iron ores in Virginia in 1911 and 1912, shows a decided falling off, both in quantity and value, from that of the two previous years, 1909 and 1910. The production in 1912 was the lowest of any single year during the last five-year period. It was 412,520 long tons, valued at $903,130, as compared with 610,871 long tons, valued at $1,146,188 in 1911, a decrease of 198,351 long tons in quantity and $243,058 in value.

The 1911 production of iron ores in the State represented the output from forty-two mines distributed among fourteen producers operating in the same number of counties (14); as against twenty-nine mines distributed among eight producers operating in ten counties in 1912.

The counties producing iron ore in Virginia during 1911 were: Alleghany, Augusta, Bedford, Botetourt, Carroll, Craig, Grayson, Lee, Page, Pittsylvania, Pulaski, Roanoke, Rockbridge, and Wythe. Those producing in 1912 were: Alleghany, Bedford, Botetourt, Craig, Lee, Pulaski, Roanoke, Rockbridge, Warren, and Wythe.

There is given in the table below the total production of iron ore in Virginia, by varieties, from 1908 to 1912, inclusive. It will be observed that brown hematite is vastly the most important variety, amounting at present to 88.5 per cent of the total production. Red hematite is next in order of importance, amounting to 11.5 per cent of the total production in 1912. The production of magnetite in 1911 was small; there being only one producer. There was no reported production of magnetite in 1912.

Production of Iron Ore in Virginia, by varieties, 1908-1912, in long tons.

Year	Brown hematite	Red hematite and magnetite	Total quantity	Total value
1908	626,910	65,313	692,223	$1,465,691
1909	762,937	74,910	837,847	1,693,188
1910	821,131	82,246	903,377	1,845,144
1911	541,870	69,001	610,871	1,146,188
1912	365,048	47,472	412,520	903,130

The average price per long ton of the different varieties of iron ore produced in Virginia during 1912 follows: Brown hematite $2.26, as against $1.91 in 1911 and $2.07 in 1910; red hematite $1.62, as against $1.58 in 1911 and $1.74 in 1910; and magnetite $1.50, being the same as the average value per ton of magnetite in 1910 and 1911. These prices represent the value of the ore at the mouth of the mine, and are taken directly from the replies of the producers.

Owing to the fact that there were less than three producers in most of the producing counties of iron ores during 1912, the production by counties can not be given. Named in the order of production the counties were: Botetourt, Wythe, Craig, Alleghany, Pulaski, Lee, Roanoke, Bedford, Rockbridge, and Warren.

On December 31, 1912, one furnace was building in Virginia, which will use mineral fuel; one was rebuilding; and in addition one coke furnace was partly erected.

The production of pig iron in Virginia during 1912 amounted to 328,961 long tons, valued at $4,364,708, as compared with 308,789 long tons, valued at $3,898,285 in 1911, and 444,976 long tons, valued at $6,150,000 in 1910.

There is given in the table below the production of pig iron in Virginia for the years 1905 to 1912, inclusive.

Production of Pig Iron in Virginia, by years, 1905-1912.

Year	Quantity Long tons	Value	Value per ton
1905	510,210	$7,540,000[a]	$14.78
1906	483,525	8,591,000[a]	17.77
1907	478,771	8,963,000	18.72
1908	320,458[b]	4,578,000	14.29
1909	391,134[b]	5,550,000	14.19
1910	444,976[b]	6,150,000	13.82
1911	308,789	3,898,285	12.62
1912	328,961[c]	4,364,708	13.27

aEstimated.
bBirkinbine, J. Personal communication.
cParker, E. W. Personal communication.

LIST OF IRON ORE PRODUCERS.

OPERATOR	OFFICE	MINE
Alleghany Ore & Iron Co	Iron Gate	Dixie, Oriskany
Barr Ore & Iron Corporation	Pittsville	Barr
Boone's Path Iron Co	Baltimore, Md.	Rose Hill Station
Crescent Iron Ore Co	New York, N. Y.	Crescent
Ivanhoe Furnace Co	Pittsburgh, Pa.	Bailey Crockett, Fries, Gregory, Ivanhoe
Longdale Iron Co	Longdale	Circle, Longdale
Lowmoor Iron Co. of Virginia	Lowmoor	Dolly Ann, Fenwick, Horse Mountain, Jordan
Oriskany Ore & Iron Corporation, Lessees Alleghany Ore & Iron Co	Iron Gate	Dixie
Paint Bank Ore Co	Paint Bank	Paint Bank
Princess Furnace Co	Glen Wilton	Callie, Wilton
Pulaski Iron Co	Pulaski	Arcadia, Clayton, Faris, Norma, Porter, Rustin, Tasker, Thomas, Tipton

OPERATOR	OFFICE	MINE
Seibel, H. J., Jr.	Happy Creek	Seibel
Virginia Iron, Coal & Coke Co.	Roanoke	Barren Springs Cedar Run Dewey Fenwick Grubb Hurst Little Wythe Percival Potts Valley Morris Reed Island Rich Hill Rustin Sanders Tasker Thaxton Trout
West End Furnace Co.	Roanoke	Greenville
Worrell, N. J.	Sylvatus	High Rock
Zinns Iron Mining Co.	Washington, Pa.	Marys Creek

MANGANESE ORES.

Virginia has always been the principal producer of manganese ores in the United States. The figures of production in 1912 were 1,537 long tons, valued at $14,881, as compared with 2,455 long tons, valued at $24,546 in 1911. The figures represent a small increase in 1911 over that of 1910, but a decrease in 1912. Notwithstanding this decrease Virginia, as heretofore, exceeded in output all other states combined.

In addition to the figures given above, 1,405 long tons of manganese ore were reported as stock on hand at the close of 1911, and 410 long tons at the close of 1912.

There were 6 producers in 1911, and 5 in 1912. The following 5 counties contributed to the 1911 production: Augusta, Campbell, Rockbridge, Rockingham, and Warren. In 1912 the producing counties were: Augusta, Campbell, Rockbridge, and Rockingham.

There are given in the table below the figures of production and value of manganese ores in Virginia from 1908-1912, inclusive.

Production and value of Manganese Ores in Virginia, 1908-1912.

Year	Quantity Long tons	Value	Average value per ton
1908	6,144[a]	$62,776	$10.22
1909	1,334[b]	14,725	10.70
1910	2,059[b]	18,509	8.98
1911	2,455	24,546	10.00
1912	1,537	14,881	9.68

[a] In addition, 274 long tons of manganiferous iron ore were sold.
[b] Includes small production of manganiferous ore.

Greater interest and activity were manifested in manganese mining in Virginia during 1912 than for several years past. The Piedmont Manganese Corporation, operating in Campbell County, and the Pittsburgh Manganese Company, operating near Elkton, were engaged chiefly in developing their mines preparatory for steady productions.

The production of manganiferous iron ores in 1912 is included under "Other Products," since it came from only two producers.

LIST OF MANGANESE PRODUCERS.

OPERATOR	OFFICE	MINE
Cox, Charles W., Assignee, Henry W. Poor & Co.	New York, N. Y.	Crimora
Evington Manganese Co.	Evington	Evington
Lucas, H. L.	Leesville	Leesville
Metal Mfg. Co. (Succeeded by Niess Waner Co.)	Elkton	Elkton
Niess-Waner Co.	Elkton	Elkton
Piedmont Manganese Corporation of Virginia	Lynchburg	10 miles east of Lynchburg
Schultz, F. W.	Baltimore, Md.	Midvale
Seibel, H. J., Jr., Prop., and L. G. Lackey, Supt.	Happy Creek and Philadelphia, Pa.	Happy Creek
Shenandoah Ore Co., Inc.	Stuarts Draft	Stuarts Draft (6 miles from)

GOLD AND SILVER.

The production of precious metals, gold and silver, in Virginia during the years 1911 and 1912, was variable, as indicated in the following figures: Gold in 1911 amounted to 148.22 fine ounces, valued at $3,064, as compared with 10.54 fine ounces, valued at $218 in 1912, a very marked decrease; silver 21 fine ounces, valued at $11 in 1911, against 982 fine ounces, valued at $604, in 1912.

In 1911, the gold and silver produced in Virginia was 105.26 fine ounces in quantity and $2,176 in value more than in 1910. Of the gold produced 39.09 fine ounces were derived from placers and 109.13 from siliceous ores; of the silver produced 7 fine ounces came from deep mines and 14 fine ounces from siliceous ores. Of the 13 properties producing, 5 were placers. According to McCaskey, 1,761 tons of gold quartz ores were treated with an average extraction value of $1.29 per ton.

In 1912, the gold production was derived entirely from siliceous ores. According to McCaskey 45 tons of Virginia siliceous ores were treated with an average precious metal recovery of $2.98 per ton. The silver production for the same year was derived from 1,160 short tons of copper ores. The 1912 production of precious metals in the State was derived from Fauquier, Goochland, and Prince William counties. No production from placer mining in the State was reported in 1912.

In Halifax County development work was in progress at the Poole gold mine and the erection of a stamp mill was contemplated.

In Spottsylvania County, the Holladay mine of mixed sulphides of lead, zinc, and iron with copper, and yielding small values in gold and silver, has been opened to a depth of 150 feet. The ore body, carrying large values in lead and zinc, has a width up to 20 feet and for the depth opened is a most encouraging prospect. The country rock is schist. In addition to the shaft some open-pit prospecting has been done, and in 1912 diamond drilling was in progress. Development work was also under way during 1912 by John M. Holladay and Son on the adjoining property, known as the Grindstone, which was worked for gold many years ago. The report[a] just issued by the Virginia Geological Survey on the gold deposits of the James River Basin, including the counties of Buckingham, Fluvanna, Goochland, and Cumberland, should revive interest in gold mining in that section of the State.

The following table, taken from Mineral Resources of the United States for 1912, shows the production of gold, silver, copper, lead, and zinc in Virginia for the years 1905 to 1912, inclusive.

Tonnage of ore treated and mine production of metals in Virginia, 1905-1912.

Year	Ore sold or treated	Gold[a]	Silver[a]	Copper	Lead	Zinc	Total value
	Short tons	*Value*	*Fine ounces*	*Pounds*	*Pounds*	*Pounds*	
1905	800	$ 4,982	177	....	....	....	$ 5,087
1906	1,000	14,832	250	....	....	....	15,000
1907	26,822	8,288	221	58,880	118,400	....	26,485
1908	12,877	2,451	236	24,775	76,190	1,410,961	75,861
1909	14,075	3,750	4,825	224,162	....	116,627	41,698
1910	16,976	888	128	5,402	198,850	1,588,112	96,151
1911	17,782	3,064	21	90,000	830,542	2,064,818	169,394
1912	5,790	218	982	111,835	469,026	497,235	74,855
Increase (+) or decrease (—) in 1912	—11,992	—2,846	—961	+21,835	—361,516	—1,567,583	—94,539

[a]Includes placer gold and silver.

COPPER.

The production of copper in Virginia in 1911 was 90,000 pounds, valued at $11,250; and in 1912, 112,835 pounds, valued at $18,618, an increase of 32,835 pounds in quantity and $7,368 in value. The production in 1912 was derived from 1,160 short tons of copper ores and from mine

[a]Taber, Stephen. Geology of the Gold Belt in the James River Basin Virginia, Va. Geol. Survey, Bull. VII, 1913, 271 pages.

waters of the pyrite mines in Louisa and Prince William counties. There was no production of copper in 1912 reported from the mines of the Virgilina district in Halifax County. Annual statistics of copper production in Virginia for the years 1905 to 1912, inclusive, are given in the table on page 7.

LEAD AND ZINC.

There was an important production of both lead and zinc in Virginia in 1911 and 1912, but there was a marked decrease in both in 1912 from that of 1911. The figures are, according to McCaskey: Lead 830,542 pounds, valued at $37,374 in 1911, against 469,026 pounds, valued at $21,106 in 1912, a decrease of 361,516 pounds in quantity and $16,278 in value; zinc 2,064,818 pounds (figured as spelter), valued at $117,695 in 1911, as compared with 497,235 pounds, valued at $34,309 in 1912, a decrease of 1,567,583 pounds in quantity and $83,386 in value.

The Austinville, Bertha, and Little Wythe mines, in Wythe County, produced lead and zinc in 1912. McCaskey has summarized the 1912 production from this county as follows:[a] "The output is from both ore and old tailings, which are concentrated. A small tonnage of ore was also shipped crude. Part of the concentrates and soft ore were treated in the Austinville oxide plant and the remainder was shipped. At the Little Wythe mine, near Cripple Creek, the principal production is of iron ore, but as zinc sulphides are encountered in streaks they are mined, hand-sorted, and shipped crude to zinc smelters."

The annual statistics of lead and zinc production in Virginia for the years 1905 to 1912, inclusive, are given in the table on page 7.

TIN.

Though not a producer of tin, the existence of tin ore of excellent quality in the Irish Creek area of Rockbridge County has been known for many years, and in 1883 and later the deposits were opened in several places.

COAL.

The coal areas of Virginia which have produced or are producing are (1) the Richmond coal basin in the eastern border of the Piedmont

[a]Advance chapter from Mineral Resources of the United States, Calendar Year 1912, p. 21.

Plateau, and the only area of free-burning coal in the eastern portion of the United States that is located immediately adjacent to tidewater; and (2) the Appalachian region west of the Blue Ridge and which comprises a number of separate areas extending entirely across the State from Frederick County on the north to the Tennessee boundary on the south.

Geologically, the Virginia coal deposits are grouped as (1) those of Triassic age, including the Richmond coal basin, and (2) those of Carboniferous age, which includes all coal deposits found west of the Blue Ridge. Of the Carboniferous coal deposits, those of the Mountain Falls district, Frederick County; the North River area, Augusta County; the North Mountain area, Botetourt County; the Montgomery-Pulaski counties area; and the Bland-Wythe counties area are Mississippian (Lower Carboniferous) in age. The Virginia portion of the Appalachian coal field, which includes the extreme southwest counties along the borders of West Virginia and Kentucky, and to which the State owes its rank as a coal producer, is Pennsylvanian (Upper Carboniferous) in age.

The southwest Virginia area (Pennsylvanian), including the Pocahontas and Big Stone Gap coal fields, is estimated to contain 1,550 square miles. The Virginia Geological Survey in coöperation with the U. S. Geological Survey is engaged in systematic study, including detailed topographic and geologic mapping of this entire area, after the completion of which an elaborate report will be prepared and published by the State Geological Survey. The area comprises all or a part of the following counties: Buchanan, Dickenson, Lee, Russell, Scott, Tazewell, and Wise. Of these, Wise, Tazewell, and Lee counties are the most important producers at present. The other counties contain large reserves of coal which are rapidly undergoing development.

The mining of coal on an extensive scale in southwest Virginia began with the opening up of the Pocahontas field in 1883 and ten years later the development of the Wise County coal field. In 1905 the Black Mountain district of Lee County was made available, and the first shipments began in 1907. Lee County is now producing at the rate of 750,000 tons a year. The production has increased in Russell County from about 220,000 tons in 1908 to more than 1,200,000 tons in 1912.

Reopening of the old Gayton mines in Henrico County about four years ago has revived interest in coal mining in the Richmond basin, and a large tonnage was reported for each of the years 1911 and 1912.

The quantity and value of coal mined in Virginia in 1912, exceeded by nearly a million tons in quantity and more than one and a quarter

million dollars in value the production of any previous year. The figures were 7,846,638 short tons, valued at $7,518,576, an increase of 981,971 short tons in quantity, and $1,263,772 in value over 1911. More than 75 per cent of the total increase was from Wise County, whose production in 1912 was 4,500,174 short tons, against 3,754,360 short tons in 1911, a gain of 745,814 short tons, or nearly 20 per cent. In 1912, 47.7 per cent of the total coal mined was shot off the solid, and 35.6 in 1911. The number of machines increased from 156 in 1911 to 185 in 1912. Likewise the machine-mined coal increased from 2,551,627, or 37.1 per cent of the total, in 1911, to 3,205,504 tons, or 40.8 per cent, in 1912. The quantity of coal mined by hand in 1912 was 898,821 tons, as compared with 1,865,320 tons in 1911. The average price per ton of coal mined in Virginia in 1912 was 96 cents, against 91 cents in 1911.

The coal mining industry in Virginia during 1911 showed a very marked increase over the production for 1910, in which year it will be recalled the high-water mark was reached in the production of coal in the State. The figures of production were 6,864,667 short tons, valued at $6,254,804. Compared with the 1910 production, the increase in quantity was 356,670 short tons, and in value $377,318. The production in Wise County increased from 3,730,992 short tons in 1910 to 3,754,360 short tons in 1911; in Tazewell, from 1,187,146 short tons in 1910 to 1,281,224 short tons in 1911; and in Montgomery, from 7,699 short tons in 1910 to 8,462 short tons in 1911. The production in Lee County decreased from 797,096 short tons in 1910 to 720,695 short tons in 1911.

In order to avoid disclosing individual production, the figures for Henrico, Pulaski, and Russell counties are combined, and, for the same reason, it is not possible to compare the 1911 production in these three counties with that of the preceding year. The production of Henrico, Pulaski, and Russell counties combined was 1,098,594 short tons, valued at $996,209. The average price per ton in 1911 was 91 cents, as against 90 cents in 1910, and 89 cents in 1909. The number of mining machines increased from 142 in 1910 to 156 in 1911, and the machine-mined coal from 2,290,435 short tons in 1910 to 2,551,627 short tons in 1911, 27.2 per cent of the total quantity of coal mined in 1911.

The accompanying table gives the quantity and value of coal produced in Virginia from 1908 to 1912, inclusive.

Quantity and value of Coal produced in Virginia, 1908 to 1912, inclusive.

Year	Quantity (short tons)	Value
1908	4,259,042	$3,868,254
1909	4,752,217	4,251,056
1910	6,507,997	5,877,486
1911	6,864,667	6,254,804
1912	7,846,638	7,518,576

The production of coal by counties in 1911 and 1912 and its distribution for consumption are given in the tables below:

Coal production of Virginia in 1911 and 1912, in short tons.

1911

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Lee	667,611	5,656	21,830	25,598	720,695	$ 724,498	$1.01	250	776
Tazewell	1,027,786	25,682	38,389	189,367	1,281,224	1,209,138	.94	210	1,352
Wise	2,470,449	39,769	80,343	1,154,799	3,754,360	3,301,984	.88	274	3,582
Other counties[a] and small mines.........	1,065,048	11,242	32,098	....	1,108,388	1,019,184	.92	279	1,682
Total	5,230,894	82,349	181,660	1,369,764	6,864,667	6,254,804	.91	261	7,392

1912

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Lee	718,570	5,245	15,725	11,736	751,276	$ 875,092	$1.16	269	1,081
Tazewell	1,057,788	26,369	36,805	181,081	1,302,043	1,318,762	1.01	203	1,367
Wise	3,008,443	65,277	90,872	1,335,582	4,500,174	4,094,905	.91	261	4,451
Other counties[a] and small mines.........	1,242,911	10,766	39,468	....	1,293,145	1,229,817	.95	252	1,779
Total	6,027,712	107,657	182,870	1,528,399	7,846,638	7,518,576	.96	251	8,678

[a]Henrico, Montgomery, Pulaski, and Russell.

There is given in the table below the production of coal in Virginia from 1908 to 1912, inclusive, by counties.

Coal production of Virginia, 1908-1912, by counties, in short tons.

County	1908	1909	1910	1911	1912	Increase (+) or decrease (—) 1912
Lee	....	....	797,096	720,695	751,276	+ 30,581
Tazewell	980,014	975,665	1,187,146	1,281,224	1,302,043	+ 20,819
Wise	2,558,874	2,841,448	3,730,992	3,754,360	4,500,174	+ 745,814
Russell	[a]719,954	[a]931,276	[b]790,066	[b]1,107,056	[b]1,292,365	+ 185,309
Small mines	200	3,828	2,697	1,332	780	— 552
Total	4,259,042	4,752,217	6,507,997	6,864,667	7,846,638	+ 981,971
Total value	$3,868,524	$4,251,056	$5,877,486	$6,254,804	$7,518,576	+$1,263,772

[a]Includes Lee, Montgomery, and Pulaski counties.
[b]Includes Henrico, Montgomery, and Pulaski counties.

LIST OF COAL PRODUCERS.

OPERATOR	OFFICE	MINE
Beacham Coal Co.	Christiansburg	Beacham
Big Town Hill Creek Coal Corporation	Richlands	Big Town Hill
Big Vein Pocahontas Coal Co.	Pocahontas	Big Vein No. 1
Black Mountain Mining Co.	Big Stone Gap	Kamont
Blacksburg Mining & Mfg. Co.	Cambria	Snider Hill
Blackwood Coal & Coke Co.	Blackwood	Blackwood, Pardee, and Roaring Fork
Blue Ridge Coal Co.	Roanoke	Blue Ridge
Bond Coal Co.	Tacoma	Greeno
Bondurant Coal & Coke Co.	Pennington Gap	Bondurant
Bruce Coal & Coke Co.	Coeburn	Bruce
Buchanan Lumber & Coal Co.	Camden, N. J.	Prospect
Clinchfield Coal Corporation	Dante	Clinchfield, Cranes Nest, and Dante
Clinch River Coal Co.	Richlands	Clinch River
Colonial Coal & Coke Co.	Dorchester	Dorchester
Darby Coal Mining Co.	Darbyville	Darby
Domestic Coal Co.	Raven	Domestic
Dominion Coal Co.	Pennington Gap	Mabel Edgar
Empire Coal Land Corporation	Alfredton	Seaboard
Esser Coal & Coke Co.	Esserville	Esserville
Fleming & Co., Robert	Norton	Banner
Fork Ridge Coal Co.	Asheville, N. C.	Greeno
Goodloe Bros. Co., Inc.	Big Stone Gap	Pin Hook
Gray Coal Co.	Pennington Gap	Jew
Hall & Robinett (Formerly N. E. Dickenson)	Coeburn	Dickenson
Huettel Coal Co.	Norton	Huettel
Intermont Coal & Iron Co.	Big Stone Gap	Josephine
Jewell Ridge Coal Corporation	Tazewell	Jewell Ridge
Kinzer & Son	Vicar Switch	Stroubles Creek
Lipps Coal Co.	Wise	Lipps
Monarch Coal Co.	Cincinnati, Ohio	Leona
Norton Coal Co.	Norton	Norton No. 2
Old Dominion Development Co.	Richmond	Carbon Hill
Pocahontas Consolidated Collieries Co.	New York, N. Y.	Boissevain and Pocahontas
Pulaski Anthracite Coal Co.	Parrott, and New York, N. Y.	Parrott
Raven Fuel Co.	Red Ash (Raven)	Raven
Raven Red Ash Fuel Co.	Red Ash	Red Ash
Slusser & Co., M. C.	Blacksburg	Brush Mountain
Southern Anthracite Coal Co.	Roanoke	Clear Air
Southern Pocahontas Coal Co.	Richlands	Sater
Stonega Coke & Coal Co.	Big Stone Gap	Arno, Imboden, Keokee, Osaka, Roda, and Stonega

OPERATOR	OFFICE	MINE
Stonegap Colliery Co.	Glamorgan	Glamorgan
Sutherland Coal & Coke Co.	Dorchester	Sutherland
Town Hill Coal Co.	Bluefield, W. Va.	Town Hill
Virginia City Colliery Co.	Virginia City	Virginia City
Virginia Iron, Coal & Coke Co.	Roanoke	Imperial, Inman, Linden, Marion, Toms Creek
Virginia Lee Co., Inc.	St. Charles	Virginia Lee
Virginia-Tennessee Coal Co.	Knoxville, Tenn.	Coal Creek
Wise Coal & Coke Co.	Dorchester	Wise
Yellow Creek Coal & Coke Co., Inc.	Wise	Yellow Creek

COKE.

The coking coals of Virginia are confined to the coal-producing counties in the extreme southwestern part of the State. Development of the region began in 1883. Virginia is handicapped in the manufacture of coke by the fact that it has but few local markets for its product.

The production of coke in Virginia during 1912 amounted to 967,947 short tons, valued at $1,815,975, against 910,411 short tons, valued at $1,615,609 in 1911, an increase of 57,536 short tons, or 6.32 per cent, in quantity, and $200,366, or 12.4 per cent, in value.

The number of coke-making establishments was 18 for each of the years 1911 and 1912. The total number of ovens was reduced from 5,496 to 5,408, which represents an abandonment of 88 ovens during the year. There were 2,976 ovens in operation in 1912 and 2,273 in 1911. The average value of coke per ton in 1911 was $1.77, and in 1912, $1.88.

Of the 1911 production of coke (1,615,609 short tons) in Virginia, 759,789 short tons came from Wise County, with a value of $883,029. The other counties producing in 1911, listed in order of production, were: Tazewell, Lee, and Alleghany. Of the total coke production in 1912 (967,947 short tons), 843,474 short tons, valued at $1,572,633, came from Wise County. Named in order of production, the other counties producing in 1912 were: Tazewell, Alleghany, and Lee.

The statistics of the manufacture of coke in Virginia from 1908 to 1912, inclusive, are shown in the following table.

Statistics of the manufacture of Coke in Virginia, 1908-1912.

Year	Establishments	Ovens		Coal used (short tons)	Yield of coal in coke (per cent)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens per ton
		Built	Building					
1908	19	4,858	158	1,785,281	65.1	1,162,051	$2,121,980	$1.83
1909	19	5,469	100	2,060,518	65.1	1,347,478	2,415,769	1.79
1910	18	5,389	100	2,310,742	64.6	1,498,655	2,731,348	1.83
1911	18	5,496	100	1,425,303	63.9	910,411	1,615,609	1.77
1912	18	5,408	0	1,555,969	62.2	967,947	1,815,975	1.88

All the coal used in coke-making in Virginia is of exceptionally high grade and requires no preparation before charging into the ovens, save that of crushing. Hence, all the coal used in the manufacture of coke in the State during the years 1911 and 1912 was unwashed. Of the 1,425,303 short tons of coal made into coke during 1911, 749,806 were slack and 675,497 were run-of-mine. Of the total quantity of coal (1,555,969 short tons) used in the manufacture of coke in 1912, 762,950 short tons were unwashed slack and 793,019 short tons were unwashed run-of-mine.

The character of the coal used in coke-making in Virginia during the last five-year period (1908 to 1912) is shown in the table below.

Character of Coal used in the manufacture of Coke in Virginia, 1908-1912, in short tons.

Year	Run-of-Mine (Unwashed)	Slack (Unwashed)	Total
1908	1,438,754	346,527	1,785,281
1909	1,405,111	655,407	2,060,518
1910	1,554,784	755,958	2,310,742
1911	675,497	749,806	1,425,303
1912	762,950	793,019	1,555,969

LIST OF COKE PRODUCERS.

OPERATOR	OFFICE	MINE
Blackwood Coal & Coke Co.	Blackwood	Blackwood
Colonial Coal & Coke Co.	Dorchester	Dorchester
Empire Coal Land Corporation	Alfredton	Richlands
Intermont Coal & Iron Co.	Big Stone Gap	Norton
Lowmoor Iron Co. of Virginia	Lowmoor	Covington and Lowmoor
Norton Coal Co.	Norton	Norton
Pocahontas Consolidated Collieries Co., Inc.	Pocahontas	Pocahontas
Stonega Coke & Coal Co.	Big Stone Gap	Imboden, Keokee, Osaka, and Stonega
Stonegap Colliery Co.	Glamorgan	Glamorgan
Sutherland Coal & Coke Co.	Dorchester	Dorchester
Virginia Iron, Coal & Coke Co.	Roanoke	Appalachia and Toms Creek
Wise Coal & Coke Co.	Dorchester	Dorchester

CLAYS AND CLAY PRODUCTS.

In 1911, the total value of all clay products in Virginia, including the value of pottery products, fire clay, and miscellaneous clay mined and sold in the State, amounted to $1,743,007, a decrease of $98.724 over 1910. The 1912 production amounted to $1,884,743 in value, an increase of $141,736, or 8.13 per cent over 1911. The principal clay

product in the State is common brick, with front brick ranking second, valued at $313,555 in 1912. Alexandria and Henrico are the two principal common brick-producing counties, with Washington, D. C., and Richmond their chief sources of supply.

The table on page 16 gives the statistics of clay products in Virginia from 1908 to 1912, inclusive. The item "Miscellaneous" in the table includes all products not otherwise specified, such as fire clay, pipe clay, clay for moulding, fancy or ornamental brick, fire brick, sewer pipe, and pottery products. In order to avoid disclosing individual production, it becomes necessary to combine these items under a single head.

From the accompanying table it will be seen that the total number of common and front brick manufactured in Virginia in 1911 was 240,067,000, valued at $1,688,640, distributed as follows: 219,035,000 common brick, valued at $1,374,439.00, and 21,032,000 front brick, valued at $314,201. The average value per thousand in 1911 was: Common brick, $6.27; front brick, $14.94.

The total number of common and front brick manufactured in Virginia in 1912 was 266,296,000, valued at $1,826,889, an increase of 26,229,000 in quantity, and $138,249 in value over the 1911 production. Of the 1912 production, 244,541,000 were common brick, valued at $1,513,338, and 21,755,000 front brick, valued at $313,551. The average value per thousand in 1912 was: Common brick, $6.19; front brick, $14.41.

The total number of fancy or ornamental brick and of fire brick produced in Virginia during 1911 and 1912 must be concealed in order to avoid disclosing figures of individual production. For the same reason it is not possible to give the production of common brick, by counties, during each of the years 1911 and 1912, except for the following counties: During 1911, Alexandria, 56,130 M, valued at $339,448; Augusta, 895 M, valued at $6,900; Henrico, 38,489 M, valued at $254,544; and Nansemond, 13,606 M, valued at $70,803; and during 1912, Alexandria, 53,671 M, valued at $294,590; Augusta, 653 M, valued at $4,885; Chesterfield, 12,144 M, valued at $71,459; Fairfax, 12,326 M, valued at $96,552; Henrico, 53,232 M, valued at $334,108; and Nansemond, 14,415 M, valued at $79,131.

Clay Products in Virginia from 1908 to 1912, inclusive.

Product	1908	1909	1910	1911	1912
Brick:					
Common—					
Quantity	185,738,000	249,794,000	229,982,000	219,035,000	244,541,000
Value	$1,219,946.00	$1,540,648.00	$1,460,460.00	$1,374,439.00	$1,513,338.00
Average per thousand........	$6.57	$6.13	$6.35	$6.27	$6.19
Front—					
Quantity	17,858,000	24,717,000	20,813,000	21,032,000	21,755,000
Value	$246,623.00	$333,057.00	$294,348.00	$314,201.00	$313,551.00
Average per thousand........	$13.81	$13.48	$14.14	$14.94	$14.41
Fancy or ornamental. Value..	(a)	(a)	(a)	(a)	(a)
Fire. Value	(a)	(a)	$5,276.00	$10,875.00	$19,831.00
Drain tile. Value	$7,100.00	$6,298.00	(a)	(a)	(a)
Sewer pipe. Value	....	(a)	(a)	(a)	(a)
Pottery. Value	(a)	(a)	(a)	(a)	(a)
Miscellaneous. Value	$66,488.00	$77,364.00	$81,647.00	$43,492.00	$38,023.00
Total value	$1,540,157.00	$1,957,367.00	$1,841,731.00	$1,743,007.00	$1,884,743.00
Number of operating firms reporting	82	89	87	82	79

LIST OF CLAY PRODUCERS.

Brick and Tile.

OPERATOR	OFFICE	WORKS
Adams & Cannon	Blackstone	Blackstone
Adams Bros.-Paynes Co., Lynchburg Brick Works, Props	Lynchburg	Deacon
Adams, Payne & Gleaves, Inc	Roanoke	Roanoke
Alleghany Brick Co., Inc	Covington	Covington
Altavista Brick Co., Inc. (Formerly Frazier Lbr. Co.)	Altavista	Altavista
Baltimore Brick Co	Richmond	Rocketts
Barr, E. M	Winchester	Winchester
Billhimer, W. H	Harrisonburg	Harrisonburg
Blackburn & Lohr	Staunton	Staunton
Booker Brick Co	Morrison	Morrison
Boston Brick Co	South Boston	Houston and South Boston
Branson, Joseph	Staunton	Staunton
Brister & Turner	Petersburg	Ettricks
Brooks, A. M., & Son	New River	Radford
Bromilaw Brick Co	Alexandria	Alexandria
Buck, E. G., Recvr. Norton Brick and Mfg. Co	Norton	Norton
Buck, Levin T., & Co	Weems	Weems
Burroughs & Mankin, Inc	Richmond	Manbur
Champe, John A	Lexington	Lexington
Charlottesville Brick Co	Charlottesville	Charlottesville
Cheatwood & Blunt	Richmond	Richmond
Clarke & Covington	Culpeper	Elkwood
Clark & Crupper	Washington, D. C.	Arlington
Cole & Son, W. C. (Formerly Galax Brick Co.)	Galax	Galax
Covington Brick Co. (Formerly Isaac Clark)	Covington	Covington
Coyner, J. M	Basic City	Basic City
Croushorn, B. G., Lessee of H. V. Croushorn, Prop	Weyers Cave	Weyers Cave
Culpeper Brick Co	Culpeper	Elkwood
Davis, W. Benjamin, Brick Co., Inc	Richmond	Manchester
Dickinson Fire Brick Co	Buena Vista	Buena Vista
District of Columbia Workhouse, Brick Mfg. Dept	Occoquan	Lee District
Eureka Brick Co	Norfolk	Lynnhaven
Face, E. W., & Son	Norfolk	Norfolk
Fitzgerald, N. A. & T. J	Danville	Danville
Franklin Brick Co	Franklin	Franklin
Fulton Brick Works	Richmond	Richmond
Hoshour, John S., & Son	Woodstock	Front Royal and Woodstock
Holdaway, R. L	Major	Major
Hydraulic-Press Brick Co	Washington, D. C.	Waterloo
James River Brick Co., Inc	Norfolk	Sturgeon Point
Jones, W. L	Williamsburg	James City
Kenbridge Brick Co	Kenbridge	Kenbridge
Kincaid, B. F., & Son	Boones Path	Rose Hill
King Mountain Brick Co	Abingdon	Abingdon
Larson, A. C	Hampton	Suffolk
Lawrenceville Brick & Tile Co., Inc	Norfolk	Lawrenceville
Legg, John W	Stevensburg	Stevensburg
Lemley, L. F., & Sons	Strasburg	Strasburg
Mayo, W. R., & Sons	Norfolk	Sturgeon Point
Mulberry Island Brick Co	Newport News	Mulberry Island
Nansemond River Brick & Tile Co	Norfolk	Reid's Ferry
New Washington Brick Co	Washington, D. C.	Abingdon
Payne & Spindler	Drakes Branch	Drakes Branch
Pierpont Brick Works	Salem	Salem
Potomac Brick Co	Washington, D. C.	Addison
Potomac River Clay Works	Alexandria	Alexandria
Powers Bros. & Maynard	Richmond	Rocketts
Radford Brick Co	Philadelphia, Pa.	Tip Top
Ready, W. J	Richmond	Henrico and Manchester
Redford Brick Works	Richmond	Manchester
Richardson, R. H., & Son	Hampton	Chickahominy River

OPERATOR	OFFICE	WORKS
Richlands Brick Corporation	Norton	Richlands
Rosslyn Brick Co	Washington, D. C.	Rosslyn
Saint Paul Normal & Industrial School	Lawrenceville	Lawrenceville
Shrum Bros	Dayton	Dayton and Harrisonburg
Southern Brick Co. (Formerly Geo. J. Fletcher)	Fredericksburg	Fredericksburg
Southside Brick Co., Inc	Richmond	Barnes Siding
Suffolk Clay Co	Suffolk	Ladysmith
Sweet Briar Institute	Sweet Briar	Sweet Briar
Tip Top Brick Co	Tip Top	Tip Top
Travis, Frank M	New London	New London
Turner, W. R	Petersburg	Ettricks
Updike, Eston	Charlottesville	Charlottesville
Virginia Brick Co	Washington, D. C.	Relee
Virginia Brick Co	Suffolk	Suffolk
Virginia Brick Works	Richmond	East Fulton
Vulcan Fire Brick Co	Baltimore, Md.	Wilmont
Walker, W. T., Brick Co	Washington, D. C.	Arlington
Ward Brick Co	Galax	Galax
Washington Brick & Terra Cotta Co	Washington, D. C.	Riverside Park
Watson-Fitzgerald Corporation	Danville	Danville and Leaksville Junction
Waverly Brick Co., Inc	Petersburg	Waverly
West Bros. Brick Co	Washington, D. C.	Relee
West End Brick Yard (W. J. Ready, Prop.)	Richmond	Henrico and Manchester
Williamson, Hedgecock & Fontaine, Inc	Martinsville	Fontaine
Wood, Dr. Geo. B	Emporia	Emporia

CLAY MINED AND SOLD.

OPERATOR	OFFICE	MINE
Branch, John P	Richmond	City Point
Dickinson Fire Brick Co	Buena Vista	Buena Vista
Vulcan Fire Brick Co	Baltimore, Md.	Wilmont
Wills, T. L	Reusens	East Reusens

POTTERY.

OPERATOR	OFFICE	MINE
Akron Smoking Pipe Co	Mogadore, Ohio	Pamplin City
Powhatan Pipe Co	Michaux	Michaux
Shenandoah Pottery Co., Ltd	Broadway	Broadway

LIME.

The production of lime in Virginia during 1911, amounting to 132,133 short tons valued at $483,016, came from 44 producers distributed among the following 13 counties: Augusta, Botetourt, Frederick, Giles, Loudoun, Montgomery, Rockbridge, Rockingham, Russell, Shenandoah, Tazewell, Warren, and Washington.

The production of lime in Virginia during 1912 amounted to 124,711 short tons, valued at $488,628. These figures, when compared with the figures of production during 1911, represent a decrease of 7,422 short tons in quantity, but an increase of $5,612 in value. There were 45 producers of lime in the State during 1912, and the production was distributed among the following 13 counties: Augusta, Bath, Botetourt, Frederick, Giles, Loudoun, Montgomery, Rockbridge, Rockingham, Russell, Shenandoah, Tazewell, and Warren.

There are given in the table below the production and value of lime in Viriginia during 1911 and 1912, by counties.

Production and value of Lime in Virginia in 1911 and 1912, by counties.

County	1911 Production Short tons	1911 Value	1912 Production Short tons	1912 Value
Augusta	3,348	$ 10,602	2,320	$ 8,114
Botetourt	22,824	85,463	20,590	74,587
Frederick	(a)	(a)	26,448	104,520
Rockingham	3,676	13,419	3,042	12,239
Shenandoah	41,418	157,067	37,021	130,053
Other counties	60,867[b]	216,465[b]	35,290[c]	159,115[c]
	132,133	$483,016	124,711	$488,628

aIncluded under other counties.
bIncludes Frederick, Giles, Loudoun, Montgomery, Rockbridge, Russell, Tazewell, Warren, and Washington counties.
cIncludes Bath, Giles, Loudoun, Montgomery, Rockbridge, Russell, Tazewell, and Warren.

In the table below is given the production of lime in Virginia in 1911 and 1912, by uses.

Production of Lime in Virginia during 1911 and 1912, by uses, in short tons.

	1911 Quantity	1911 Value	1912 Quantity	1912 Value
Building lime	63,567	$237,078	68,284	$272,859
Hydrated lime	(a)	(a)	(a)	(a)
Paper mills	15,620	59,983	(b)	(b)
Fertilizer	32,655	104,688	32,702	116,381
Tanneries	4,109	15,657	1,865	6,378
Chemical works	(b)	(b)	(b)	(b)
Dealers—uses not specified	11,149	48,000	4,000	15,000
Miscellaneous[c]	5,033	17,610	17,860	78,010
	132,133	$483,016	124,711	$488,628

aOnly a small quantity of the lime produced in Virginia is hydrated.
bIncluded under miscellaneous.
cIncludes lime for chemical works and other purposes in 1911, and lime for paper mills, chemical works, and other purposes in 1912.

LIST OF LIME PRODUCERS.

OPERATOR	OFFICE	KILN
Barley, Louis C.	Alexandria	28 miles w. of Staunton
Blankenship, S. M.	Deerfield	Deerfield
Bristol Lime & Stone Co., Inc.	Bristol, Va.-Tenn.	Benhams
Brown, C. H.	Stuarts Draft	Stuarts Draft
Conner, I. N.	Vaucluse Station	Vaucluse Station
Cooper, I. C.	Hinton	Hinton
Cupp, G. V.	Spring Creek	Spring Creek
Cupp, Stewart	Spring Creek	Spring Creek
Davis, C. W.	Blacksburg	Blacksburg
Dillon's, E., Sons	Indian Rock	Indian Rock
Driver, Ira R.	Mount Sidney	Mount Sidney
Eagle Rock Lime Co.	Eagle Rock	Eagle Rock
Eureka Lime Co.	Vicar Switch	Vicar Switch
Fellsworth Lime Works	Staunton	Staunton
Fiber, John W.	Spring Creek	Spring Creek
Fifer, John	Spring Creek	Spring Creek
Grove, M. J., Lime Co.	Limekiln, Md.	Stephens City
Harris, J. A.	Stuarts Draft	Stuarts Draft
Harris, J. W.	Stuarts Draft	Stuarts Draft
Hess, S. L.	Spring Creek	Sangerville
Hogshead, Chas. A.	Mossy Creek	Mossy Creek
Kiracofe, C. S.	Bridgewater	Bridgewater
Leesburg Lime Co., Inc.	Leesburg	Leesburg
Limeton Lime Co.	Limeton	Limeton
Linville Lime Co.	Linville	Linville
McClure, J. D.	Startannery	Startannery
McIlwee, C. E.	Zepp	Zepp
McKimmy, A. G.	Lucketts	Lucketts
Michael, J. W.	Spring Creek	Sangerville
Miller, E. E.	Bridgewater	Bridgewater
Miller, G. E.	Bridgewater	Bridgewater
Moore Lime Co.	Richmond	Eagle Mountain
Natural Bridge Lime Co.	Glasgow	Sherwood
New River Lime Co.	Ripplemead	Ripplemead
Oak Ridge Lime Firm	Mt. Solon	Mt. Solon
Orndorff, M. M.	Oranda	Oranda
Oyler, Geo. V.	Winchester	Winchester
Powhatan Lime Co.	Strasburg	Strasburg
Pullins, A. C.	Mt. Sidney	Mt. Sidney
Riverton Lime Co.	Riverton	Riverton
Rockbridge Lime & Stone Co.	Lexington	Lexington
Rockdale Lime Co.	Toms Brook	Toms Brook
Rowe, O. F.	Deerfield	Deerfield
Rusmiselle, J. A.	Mt. Solon	Mt. Solon
Shenandoah Lime Co.	Strasburg Jct.	Strasburg Jct.
Standard Lime & Stone Co.	Strasburg	Strasburg
Staunton, City of	Staunton	Staunton
Strasburg Lime Co.	Strasburg	Strasburg
Stuart Land & Cattle Co.	Elk Garden	Elk Garden
Tazewell White Lime Works	North Tazewell	North Tazewell
Thompson, T. W.	Hinton	Harrisonburg
Wheelbarger-Rumsey Lime Corporation	Dayton	Dayton

CEMENT.

There are only two plants for the manufacture of Portland cement in Virginia, namely, that of the Virginia Portland Cement Company at Fordwick, Augusta County, and that of the Norfolk Portland Cement Corporation at Norfolk. The Fordwick plant has a capacity of 1,250,000 barrels, and is selling the Old Dominion cement in the North as well as in the South. The materials used by this plant in the manufacture of Old Dominion cement are Lewistown limestone and shale. The Norfolk plant is the first plant built in the South to manufacture Portland cement from shell marl as the principal calcareous material instead of the hard

rock—limestone. The marl and clay deposits used by this plant are located on branches of James River near Smithfield and Chuckatuck.

Inasmuch as there were only two plants in Virginia producing Portland cement in 1911, the figures of production are combined with those of another subject in order to avoid disclosing individual operations. The same condition holds for the 1912 production.

LIST OF CEMENT PRODUCERS.

OPERATOR	OFFICE	PLANT
Norfolk Portland Cement Corporation	Philadelphia, Pa.	Norfolk
Virginia Portland Cement Co.	New York, N. Y.	Fordwick

SAND AND GRAVEL.

The production of sand and gravel in the State during 1912 amounted to 689,266 short tons, valued at $291,773, as compared with 553,996 short tons, valued at $204,170, in 1911. These figures represent an increase over the 1911 production of 135,270 short tons in quantity, and $87,603 in value.

In 1911, there were 31 producers, operating in 20 counties. The production by counties, during 1911, was as follows: Giles, 20,209 short tons, valued at $11,397; Henrico, 11,750 short tons, valued at $11,853; Rockingham, 25,905 short tons, valued at $8,465; Spottsylvania, 286,490 short tons, valued at $75,020; and other counties,[a] 209,642 short tons, valued at $97,435.

In 1912, there were 31 producers, operating in 21 counties. The production by counties, during 1912, was as follows: Giles, 5,878 short tons, valued at $3,074; Henrico, 10,716 short tons, valued at $9,366; Roanoke, 18,533 short tons, valued at $8,936; Rockingham, 12,080 short tons, valued at $9,718; Spottsylvania, 216,987 short tons, valued at $82,630; and other counties,[b] 425,072 short tons, valued at $178,049.

The following table shows the details of the industry, and the comparative quantities and values from 1908 to 1912, inclusive.

[a]Includes Alexandria, Alleghany, Augusta, Campbell, Caroline, Charles City, Dinwiddie, Elizabeth City, New Kent, Norfolk, Princess Anne, Pulaski, Roanoke, Scott, Shenandoah, and Wythe.

[b]Includes Alexandria, Alleghany, Augusta, Campbell, Caroline, Charles City, Dinwiddie, Elizabeth City, Hanover, New Kent, Norfolk, Pittsylvania, Princess Anne, Pulaski, Wise, and Wythe.

Production of Sand and Gravel in Virginia, 1908-1912, by uses, in short tons.

	1908		1909		1910		1911		1912	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Sand—										
Glass	....	....	....	....	700	$ 450	(a)	(a)	(a)	(a)
Molding	47,888	$ 22,568	25,480	$ 17,241	35,517	24,954	41,533	$ 18,303	21,701	$ 11,746
Building	139,742	61,378	368,744	125,208	251,170	88,340	216,756	98,675	374,894	164,456
Fire	....	....	....	....	....	....	(a)	(a)	(a)	(a)
Engine	6,651	2,860	3,594	1,585	1,900	1,165	7,843	3,220	(a)	(a)
Furnace	11,295	5,500	9,740	4,563	5,339	2,088	11,607	6,270	....	....
Other	670	325	47,631	8,149	22,494	10,628	23,500	3,775	9,595	4,279
Paving	....	....	....	....	....	....	11,079	4,275	12,250	2,688
Miscellaneous[b]	....	....	....	....	....	....	3,240	3,230	35,524	21,132
Gravel	242,988	26,464	392,287	124,431	447,201	87,791	238,438	66,422	235,302	87,472
Total	449,234	$119,095	847,476	$281,177	764,321	$215,416	553,996	$204,170	689,266	$291,773

[a]Included under miscellaneous.
[b]Includes glass sand, fire sand, grinding and polishing sand, and engine sand.

LIST OF SAND AND GRAVEL PRODUCERS.

OPERATOR	OFFICE	PIT OR BED
Appomattox Iron Works	Petersburg	Petersburg
Bickford Sand & Gravel Co	Hampton	Hampton
Botto, J. L., Sand Co	Richmond	Richmond
Bromilaw Brick Co	Alexandria	Alexandria
Calhoun, James W., & Bro	North River	North River
Clinedinst, J. S	Edinburg	Edinburg
Columbia Granite & Dredging Co	Washington, D. C.	Potomac River
Cooper Glass & Silica Co	Salem	Salem
Cowardin, S. P	Richmond	Richmond
Cuddy, W. T	Lurich	Lurich
Curlis, H. C	Holdcroft	Holdcroft
Dills, M. C	Bluff City	Pearisburg
Ellis, Atwell C	Lyndhurst	Lyndhurst
French, J. E., & Bro	Curve	Curve
French, K. S. (Sold to White Sand Co.)	Narrows	Narrows
Harbaugh, S. I., Mrs	Richmond	Richmond
Hunter, C. E., Farmers' Friend Plow Works	Fredericksburg	Fredericksburg
Lillie, George W	Richmond	Massaponax
Lowmoor Iron Co. of Virginia	Lowmoor	Lowmoor
Mercer & Miller	Richmond	Richmond
Monger, J. H	North River	Harrisonburg
National Mfg. Co., Inc	Lynchburg	Lynchburg
Norfolk Sand & Gravel Corporation	Norfolk	Hampton
Norfolk & Southern Ry. Co	Norfolk	Cape Henry
Laughon, B., & Co	Pulaski	Delton (Laughon Siding)
Port Republic Foundry	Port Republic	Port Republic
Quarles, A. G	Richmond	Richmond
Reynolds White Sand Co	Bristol	Bristol
Richmond, Fredericksburg & Potomac Ry. Co	Richmond	Fredericksburg
Shepherd, Larkin	Appalachia	Appalachia
Southern Sand & Gravel Co	Richmond	Fredericksburg
Summerman, Thomas H	Ivanhoe	Ivanhoe
Water Works Supply Corporation	Norfolk	Norfolk
Webb, J. H	Roanoke	Roanoke
Wills, T. L	Lynchburg	Lynchburg

STONE.

The stone industry in 1912 was third in importance among those based upon the mineral wealth of the State, being surpassed only by the coal and clay products. The total production exceeded in value that of the iron ores. The value of the annual production of stone in Virginia from 1908 to 1912 is given in the accompanying table.

Value of the annual production of Stone in Virginia from 1908-1912, inclusive.

Year	Granite	Sandstone	Slate	Limestone	Total
1908	$321,530	$ 2,600	$194,356	$280,542	$ 799,028
1909	488,250	28,574	180,775	342,656	1,040,255
1910	503,106	25,080	148,721	471,903	1,148,810
1911	420,611	31,315	188,808	369,872	1,010,606
1912	470,657	4,020	195,392	402,313	1,072,382

The total value of the different kinds of stone quarried for the period of years for which statistics are given, shows that the quarrying of granite

is the largest industry in stone, with limestone next, and slate third. The production of sandstone for the period represented in the table is relatively unimportant.

The value of the total production of stone in the State during 1912 was $1,072,382, against $1,010,606 in 1911, an increase in value of $61,776.

Granite.

The production of granite in the State during 1911 was valued at $420,611, against $503,106 in 1910, a decrease in value of $82,495, or nearly 16.4 per cent. Twenty-eight producers distributed among 16 counties contributed to this production. The counties were: Campbell, Chesterfield, Dinwiddie, Fairfax, Fluvanna, Goochland, Greenesville, Henrico, Loudoun, Lunenburg, Mecklenburg, Nelson, Pittsylvania, Prince William, Spottsylvania, and Stafford.

The value of the granite production in 1912 was $470,657, which represents an increase in value of $50,046 over the 1911 production. There were 15 counties producing in 1912, namely, Alexandria, Campbell, Chesterfield, Dinwiddie, Fairfax, Fluvanna, Goochland, Greenesville, Henrico, Loudoun, Lunenburg, Nelson, Pittsylvania, Prince William, and Stafford, and the output was distributed among 25 producers.

There are given in the table below the value and uses of the granite and gneiss quarried in Virginia during the years 1908 to 1912, inclusive.

Value of Granite produced in Virginia, 1908-1912, by uses.

Use	1908	1909	1910	1911	1912
Sold in the rough—					
Building	$ 26,769	$ 24,965	$ 31,841	$ 9,580	$ 28,617
Monumental	12,664	1,966	3,771	8,990	8,820
Other	1,075	....	2,375	(a)	....
Dressed for building	4,000	17,750	14,750	11,948	3,852
Dressed for monumental work	29,803	9,449	6,300	(a)	7,526
Made into paving blocks	10,173	18,053	28,596	32,458	79,046
Curbing	6,130	29,100	57,511	24,149	16,774
Flagging	....	990	1,565	(a)	(a)
Rubble	18,270	33,321	38,792	27,870	32,554
Riprap	16,336	1,386	6,989	(a)	59,575
Crushed stone—					
Road-making	21,670	74,054	40,691	39,379	54,540
Railroad ballast	92,895	125,704	111,811	145,722	49,480
Concrete	81,745	147,112	156,894	104,945	115,427
Other	....	4,400	1,220	(a)	(a)
Miscellaneous[b]	....	....	....	15,570	14,446
Total	$321,530	$488,250	$503,106	$420,611	$470,657

[a]Included under miscellaneous.
[b]Includes dressed for monumental work, flagging, and other purposes.

There was a very marked increase in the number and value of granite paving blocks produced in the State in 1912.

The table below gives the number of granite paving blocks produced in Virginia, by years, from 1908 to 1912, inclusive.

Number and value of Granite Paving Blocks produced in Virginia, 1908-1912.

Year	Number	Value	Average Value per 1,000
1908	252,910	$10,173	$40.22
1909	853,300	18,053	21.16
1910	680,602	28,596	42.02
1911	872,710	32,458	37.19
1912	1,980,943	79,046	44.95

LIST OF GRANITE PRODUCERS.

OPERATOR	OFFICE	QUARRY
American Stone Co., Inc.	Richmond	Kora
Andrews, J. W., & Co.	Petersburg	Petersburg
Belmont Trap Rock Co., Inc.	Herndon	Belmont Park
Cartwright & Davis	Fredericksburg	Fredericksburg
Columbia Granite & Dredging Co.	Washington, D. C.	Washington, D. C.
Consolidated Quarry Co.	Washington, D. C.	Occoquan (near)
Danville, City of	Danville	Danville
District of Columbia, Eng. Commissioner of	Washington, D. C.	Occoquan
Electric Generating Co.	Fredericksburg	Falmouth (near)
Frazier Stone Co.	Richmond	Greenway
Gregory, Lucius	Chase City	Chase City
Harris, H. J.	Richmond	Boscobel (Harris Siding)
James River Granite Co.	Richmond	Holland Siding
Jones, H. D., Rock Co.	Lynchburg	Lynchburg
Lane Bros. Co.	Altavista	Altavista
Logan, A.	Lynchburg	Lynchburg
Lone Jack Stone Co. (Gneiss)	Lynchburg	Lynchburg
McCloy, John A., Granite Co.	Richmond	Richmond
McGowan, John	Richmond	Manchester
Markley, C.	Roanoke	Kenbridge
Miller & Kirkpatrick	Petersburg	Petersburg
Netherwood, Albin	Richmond	Richmond
Norfolk County Road Board	Skippers	Hitchcock (near Emporia)
Old Dominion Iron & Nail Works	Richmond	Richmond (Belle Isle)
Petersburg Granite Co.	Baltimore, Md.	Petersburg
Smith, Charles G., & Son	Washington, D. C.	Washington, D. C. (near)
Smith, I. J., & Co., Inc.	Richmond	Richmond
Strathmore Quarrying Co.	Richmond	Shores
Sunnyside Granite Co., Inc.	Richmond	Dunbarton Station
Virginia Granite Co.	Richmond	Dunbarton Station
Virginia State Farm	Lassiter	Lassiter
Washington Stone Co.	Washington, D. C.	Occoquan
Wray, A. J.	Richmond	Granite

Limestone.

The production of limestone in Virginia during each of the years 1911 and 1912 was below that of 1910, but the 1912 production showed a

marked increase over that of 1911. The value of the production in 1912 was $403,063, against $369,872 in 1911, an increase of $33,191, or 8.2 per cent.

There were 34 producers of limestone during 1911, operating in 16 counties as follows: Alleghany, Augusta, Botetourt, Giles, Loudoun, Montgomery, Roanoke, Rockbridge, Rockingham, Russell, Shenandoah, Smyth, Tazewell, Washington, Wise, and Wythe. There were 33 producers of limestone in Virginia in 1912, the production coming from the same counties as in 1911, except that Montgomery and Russell counties had no production, and there was one additional county, Warren, producing.

The production of limestone in Virginia from 1908 to 1912, inclusive, and the uses for which it was quarried are given in the table below:

Production of Limestone in Virginia, from 1908 to 1912, by uses.

	1908	1909	1910	1911	1912
Rough building	$ 1,870	$ 715	$ 125	$ (a)	$ 5,707
Dressed building	2,950	129	....	....	....
Paving	....	15	45	(a)	....
Curbing	79	....	750	....	....
Flagging	110	7	....	....	....
Rubble	....	3,000	3,188	....	(a)
Riprap	3,377	....	1,805	....	....
Crushed stone:					
Road-making	30,159	31,076	20,056	42,643	56,500
Railroad ballast	45,541	84,883	108,129	126,884	115,576
Concrete	26,604	8,068	36,849	40,677	41,192
Flux	169,847	213,444	294,668	143,099	130,916
Agricultural	....	....	....	4,555	20,992
Unspecified	5	1,319	6,288	431	300
Miscellaneous	....	....	....	11,583[b]	31,880[c]
Total	$280,542	$342,656	$471,903	$369,872	$403,063

aIncluded under miscellaneous.
bIncludes rough building, paving, and alkali works.
cIncludes alkali works, paper mills, rubble, and small production of marble.

LIST OF LIMESTONE PRODUCERS.

OPERATOR	OFFICE	QUARRY
Alleghany Lime Co., Inc.	Christiansburg	Houchin Station
Alleghany Ore & Iron Co.	Iron Gate	Bells Valley
Bristol Lime & Stone Co., Inc.	Bristol, Va.-Tenn.	Benhams (near)
Bunn & Co.	Big Stone Gap	Big Stone Gap
Boxley, W. W.	Roanoke	Sinking Creek
Clark County Construction Co.	Big Stone Gap	Big Stone Gap
Cooper, I. C.	Hinton	Hinton
Crigger, R. C.	Wytheville	Wytheville
Culbert, W. F.	Marion	Marion
Dillon's Sons, E.	Indian Rock	Buchanan and Indian Rock
Eagle Rock Lime Co.	Eagle Rock	Eagle Rock

OPERATOR	OFFICE	QUARRY
Fellsworth Lime Works	Staunton	Staunton
Fisher & Co., S. E.	Strasburg	Strasburg Jct.
Fishersville Lime Grinding Co.	Fishersville	Fishersville
Ivanhoe Furnace Co.	Ivanhoe	Ivanhoe
Kinzer & Vermillion	Tazewell	Tazewell
Larner & Co., William	Staunton	Staunton
Leesburg Lime Co., Inc.	Leesburg	Leesburg
Limeton Lime Co.	Limeton	Limeton
Longdale Iron Co.	Longdale	Longdale
Lowmoor Iron Co. of Virginia	Lowmoor	Lowmoor
Markley, C.	Roanoke	Roanoke
Mathews Curtis Co., Inc.	Clifton Forge	Clifton Forge
Moore Lime Co.	Richmond	Eagle Rock
Natural Bridge Lime Co.	Glasgow	Sherwood
Oriskany Ore & Iron Corporation	Iron Gate	Bells Valley
Paxton, C. H.	Natural Bridge	Natural Bridge
Peters Co., R. L.	Big Stone Gap	Big Stone Gap
Powhatan Lime Co.	Strasburg	Strasburg
Pulaski Iron Co.	Pulaski	Patterson and Ivanhoe
Riverton Lime Co.	Riverton	Riverton
Rockbridge Lime & Stone Co.	Lexington	Lexington
Rockdale Lime Co.	Toms Brook	Toms Brook
Rule, W. R.	Abingdon	Abingdon and Elk Garden
Staunton, City of	Staunton	Staunton
Stuart Land & Cattle Company	Elk Garden	Elk Garden
Vaughan Construction Co.	Roanoke	Radford and Roanoke
Virginia Iron, Coal & Coke Co.	Roanoke	Barren Springs, Buchanan, and Radford
Wells, John S.	Staunton	Staunton
Wytheville Town Quarry	Wytheville	Wytheville

Sandstone.

The production of sandstone in Virginia is slight, and it varies greatly according to the local demands. The production in 1912 was valued at $4,020, as compared with $31,315 in 1911, a decrease of $27,295. There were 3 producers during 1912, and 5 during 1911. The value of the annual production of sandstone in the State from 1908 to 1912, inclusive, is shown in the accompanying table.

Value of Sandstone production in Virginia, 1908-1912.

Year	Value
1908	$ 2,600
1909	28,574
1910	25,080
1911	31,315
1912	4,020

LIST OF SANDSTONE PRODUCERS.

OPERATOR	OFFICE	QUARRY
Gaither Construction Co.	Manassas	Nokesville
Hall, L. M.	Wise	Wise
Mathews Curtis Co., Inc.	Clifton Forge	Basic City
Peak Creek Sandstone Co.	Pulaski	Pulaski
Warden & Hailley	Pulaski	Pulaski

Slate.

There are five principal slate areas in Virginia, which, named in the order of their commercial importance, are: (1) The Arvonia belt in Buckingham and Fluvanna counties; (2) the Keswick-Esmont belt in Albemarle County; (3) the Snowden belt in Amherst and Bedford counties; (4) the Warrenton belt in Fauquier and Culpeper counties; and (5) the Quantico belt in Spottsylvania, Stafford, and Prince William counties. These are shown on map, fig. 1. The production during the years 1911 and 1912 was from the Arvonia and Keswick-Esmont belts.

In 1912, Virginia ranked fourth among the slate-producing states. The productive quarries are at Esmont, Albemarle County, and Arvonia and Penlan, Buckingham County. The product from these quarries is used exclusively for roofing.

The total production of slate in 1912 was 42,220 squares, valued at $195,392, as compared with 40,040 squares, valued at $188,808 in 1911, an increase of 2,180 squares in quantity and $6,584 in value. The average price per square in 1912 was $4.63 and in 1911, $4.72, a decrease of $0.09 per square. In 1911, there were 7 producers of slate operating in two counties, namely, Albemarle and Buckingham, as against 8 in the same counties in 1912, with the principal part of the production for each year from Buckingham County.

The amount and value of the annual production of slate in Virginia from 1908 to 1912, inclusive, are given in the accompanying table.

Production of Slate in Virginia, 1908-1912.

Year	Roofing Slate Number of Squares	Value	Average Price Per Square
1908	41,678	$194,356	$4.66
1909	40,880	180,775	4.42
1910	31,787	148,721	4.68
1911	40,040	188,808	4.72
1912	42,220	195,392	4.63

The number of squares, as given in the above table, includes both first and second qualities, and the average price per square does not give a fair indication of the prices obtained for most of the stock.

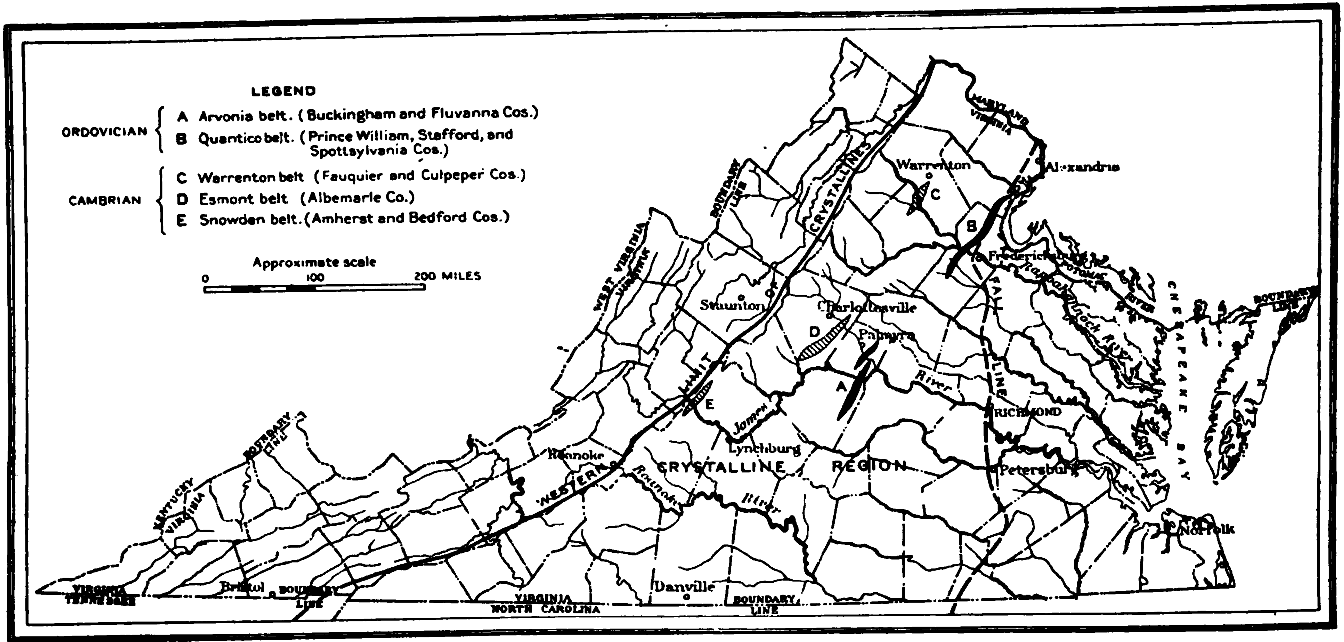

Fig. 1.—Map of Virginia showing location of slate belts.

LIST OF SLATE PRODUCERS.

OPERATOR	OFFICE	QUARRY
Buckingham Slate Co., Inc.	Richmond	Arvonia
LeSeuer Slate Co., Inc.	Orebank	Arvonia
National Slate Corporation of Virginia (Formerly New York & Buckingham Slate Co.)		Wealthia
Penlan Slate Co.	Penlan	Penlan
Pitts Slate Co., A. L.	Arvonia	Arvonia
Richmond Slate Co., Inc.	Richmond	Arvonia
Standard Slate Corporation	Esmont	Esmont
Williams Slate Co.	Arvonia	Arvonia

Crushed Stone.

The value of the production of crushed stone in Virginia in 1911 was $500,250, against $432,715 in 1912, an increase of $67,535. This material is used exclusively for road-making, railroad ballast, and concrete, and includes a wide range of rock-types, such as the crystalline siliceous rocks, limestone, etc.

The value of the crushed stone produced in Virginia from 1908 to 1912, inclusive, is given in the table below.

Value of annual production of Crushed Stone in Virginia, 1908-1912.

	Granite, Gneiss, etc.			Limestone			
Year	Road-making	Bal-last	Con-crete	Road-making	Bal-last	Con-crete	Total
1908	$ 21,670	$ 92,895	$ 81,745	$ 30,159	$ 45,541	$ 26,604	$298,614
1909	74,054	125,704	147,112	31,076	84,883	8,068	470,897
1910	40,691	111,811	156,894	20,056	108,129	36,849	474,430
1911	39,379	145,722	104,945	42,643	126,884	40,677	500,250
1912	54,540	49,480	115,427	56,500	115,576	41,192	432,715

Furnace Flux.

Limestone, used in smelting operations for flux, is quarried and shipped to the numerous blast furnaces in the State. The utilization of limestone as flux constitutes the largest consumption of the Virginia stone. Each of the principal limestone horizons in western Virginia supplies some stone as flux to the iron furnaces, but the Cambro-Ordovician and Lewistown (Helderbergian) limestones are the principal sources of stone for this purpose.

Of the total production ($369,872) of limstone in the State in 1911 only 39 per cent ($143,099) was sold as flux and utilized in the blast furnaces, and in 1912, 32 per cent was sold for the same purposes.

The value of the limestone sold as flux in 1912 was $130,916 against $143,099 in 1911, a slight decrease.

There are given in the table below the annual production and value of limestone as furnace flux in Virginia from 1908 to 1912, inclusive.

Production of Furnace Flux in Virginia, 1908-1912, in long tons.

Year	Quantity	Value
1908	290,847	$169,847
1909	388,746	213,444
1910	540,264	294,668
1911	281,968	143,099
1912	254,108	130,916

ABRASIVE MATERIALS.

Millstones (Buhrstones).

The millstone industry in Virginia is limited to the quarries in Brush Mountain, near Price's Fork, Montgomery County. A very marked increase in the production was shown for the years 1911 and 1912. The value of the production in 1911 was nearly three and a half times that of 1910, and that of 1912 was much larger than for 1911. The value of the millstone production in 1911 was $17,635 and in 1912, $25,866, an increase of $8,231. These figures represent the value of millstones of 12, 14, 15, 16, 20, 22, 24, 26, 30, 36, 42, and 48 inches in size, and of a small output of chasers (drag stones). Five operators contributed to the production for each of the years 1911 and 1912.

The value of millstones produced in Virginia from 1908 to 1912, inclusive, is given in the table below.

Value of Millstones produced in Virginia, 1908-1912, inclusive.

Year	Value
1908	$ 7,954
1909	12,348
1910	5,273
1911	17,635
1912	25,866

LIST OF ABRASIVE PRODUCERS.

OPERATOR	OFFICE	QUARRY
Cowan Millstone Co. (Formerly R. E. Snider)	Blacksburg	Brush Mountain, near Prices Fork
Linkous, F. C. & H. M.	Cambria	
Olinger, R. L., & Co.	Cambria	
Price, B. S., & Co.	Blacksburg	
Price, Zack	Cambria	

SILICA.

Under this heading are included three forms of silica which have rather wide distribution in the State. These are quartz, chert, and diatomaceous earth. There was no reported production of quartz and chert in 1911 and 1912, although preparations were in progress during 1912 for working several of the quartz deposits in 1913. The Vulcan Fire Brick Co., Baltimore, Md., with operations at Rollins Fork, King George County, was the only producer of diatomaceous earth in Virginia during the years 1911 and 1912, respectively, and, in order to avoid disclosing individual production, its output is included under "Other Products."

MICA.

Although Virginia has been an irregular producer of mica for many years, there was no production reported in 1912, and only one producer in 1911, namely, the Chestnut Mountain Mica Company, near Rocky Mount, Franklin County. Interest was revived in several of the Virginia mica mines in 1912, and active preparations were in progress for working in 1913.

LIST OF MICA OPERATORS.

OPERATOR	OFFICE	MINE
Chestnut Mountain Mica Co	Danville	Rocky Mount
Corson Mica Co	E. Stroudsburg, Pa.	Amelia
Fink, C. E. & J. B	Irwin	Irwin
Hanover Mica Co	Hewlett	Hewlett
Mecklenburg Mica & Mining Co	South Hill	South Hill
Otter Hill Mica Mines	Findlay, Ohio	Bedford City
Pinchbeck Mica Mines	Chula	Amelia C. H.
Reed, Mrs. E. P	Irwin	Irwin
Ridgeway Mica Co	Pittsburgh, Pa.	Ridgeway
Rutherford, A. H	Amelia C. H.	Amelia C. H.
Virginia Asbestos Co	Terre Haute, Ind.	Bedford City
Winston, Chas. P	Amelia C. H.	Amelia C. H.
Wooton & Fontaine	Axton	Martinsville

FELDSPAR.

The entire production of feldspar in the State during the years 1911 and 1912 was from a single operator, the Dominion State Mines Corporation, Prospect, hence the figures of production are combined with those of another subject, in order to avoid disclosing individual returns.

ASBESTOS.

No production of asbestos has been reported in Virginia since 1906. although the mineral has been noted in several of the Piedmont counties,

and has been mined in Bedford and Franklin. The mines have been inactive since 1906 and the mill at Bedford City for fiberizing the asbestos is closed.

TALC AND SOAPSTONE.

Virginia is vastly the most important producer of soapstone in the United States, exceeding both in quantity and value that of all other states combined. The production of talc and soapstone in Virginia during 1911 was 26,759 short tons, valued at $660,926, an increase of 851 short tons in quantity and $150,145 in value over that of 1910. The 1911 production was from 8 producers, operating in four counties, namely, Albemarle, Fairfax, Nelson, and Orange. In 1912 there were 8 producing quarries, operating in the counties of Albemarle, Fairfax, and Nelson. Only a small proportion of the total quantity of talc and soapstone quarried in Virginia is sold in the crude state. The production is classified in the following four groups: Rough or crude, sawed into slabs, manufactured articles, and ground.

The 1912 production was 32,665 short tons. Of this amount, 25,313 short tons valued at $576,473 were sold, a decrease of $84,453 in value from that of 1911. The decrease as indicated in the table below was shown both in the product sawed into slabs and that manufactured into articles.

The quantity and value of talc and soapstone produced in Virginia during 1911 and 1912, according to the condition in which it was marketed, are given in the subjoined table.

Production of Talc and Soapstone in Virginia during 1911 and 1912, according to varieties.

	1911		1912	
	Quantity	Value	Quantity	Value
Rough / Ground[a]	2,550	$ 16,450	3,240	$ 16,496
Sawed into slabs.............	3,384	69,631	2,527	47,596
Manufactured articles[b]	20,825	574,845	19,546	512,381
	26,759	$660,926	25,313	$576,473

[a]For paint, paper filling, complexion powders, lubricants, etc.

[b]Includes washtubs, laboratory or kitchen sinks, stove bricks, griddles, or other mill stock.

The yearly production of talc and soapstone in Virginia from 1908 to 1912, inclusive, is given in the table below.

Production of Talc and Soapstone in Virginia, 1908-1912, in short tons.

Year	Quantity	Value
1908	19,616	$458,252
1909	26,511	523,942
1910	25,908	510,781
1911	26,759	660,926
1912	25,313	576,473

LIST OF TALC AND SOAPSTONE PRODUCERS.

OPERATOR	OFFICE	QUARRY
Bull Run Talc & Soapstone Co	Clifton Station	Clifton Station
Climax Soapstone Co	Elmington, or New York, N. Y.	Elmington
Fairfax Soapstone Co	Wiehle	Wiehle
Horst, John B., & Son	Clifton Station	Clifton Station
Old Dominion Soapstone Corporation	Esmont	Damon
Phœnix Soapstone Co	New York, N. Y.	Arrington
Piedmont Soapstone Co	Asbestine	Asbestine
Utica Mining & Milling Co	Orange	Rhoadesville
Virginia Soapstone Co	Schuyler	Alberene and Schuyler
Virginia Talc & Soapstone Co	Verdiersville	Verdiersville

BARYTES.

The production of barytes in Virginia for each of the years 1911 and 1912 can not be published separately without disclosing the output of individual operations, hence the figures are combined with another subject.

LIST OF BARTYES PRODUCERS.

OPERATOR	OFFICE	MINE
Chism, Daniel C	Hurt	Pittsylvania County
Langhorne, R. H	Evington	Evington
Nulsen, Klein & Krausse Mfg. Co	St. Louis, Mo.	Toshes

GYPSUM.

Gypsum of excellent quality was mined in 1911 and 1912 by the Southern Gypsum Company at North Holston, three and a half miles northeast of Saltville, Smyth County, and by the United States Gypsum Company at Plasterco, Washington County. The crude gypsum is treated in the mills of the two companies on the respective properties, and the product put upon the market in the form of wall plaster and land plaster. The geology of these deposits is described by George W. Stose on pages 51-73 of this report.

The figures of production for each of the years 1911 and 1912 are combined with another subject, in order to avoid disclosing individual production, since there were only two producers.

LIST OF GYPSUM PRODUCERS.

OPERATOR	OFFICE	MINE
Southern Gypsum Co., Inc.	North Holston	North Holston
U. S. Gypsum Co. (a)	Chicago	Plasterco

aFormerly Buena Vista Plaster and Mining Co., Plasterco.

SALT.

Salt brines and rock salt occur in the Holston Valley of southwest Virginia in association with gypsum. More than 50 wells have been drilled, ranging in depth from 300 to 2,380 feet. These wells are confined to the immediate vicinity of Saltville, and are controlled by the Mathieson Alkali Works. Since 1903 the brines have been utilized exclusively for the manufacture of soda products, chiefiy sodium carbonate and caustic soda.

The geology of these deposits is described by George W. Stose on pages 51-73 of this report.

MINERAL PAINTS.

The production of mineral paints in Virginia during 1912 was limited to the natural product ocher and came from one producer each in Bedford and Page counties. In 1912 the production included ocher and pigments (zinc oxide, ZnO) made directly from ores. The output in ocher was from Bedford, Page, and Pulaski counties, and that of zinc oxide (ZnO) from the Bertha Mineral Company at Austinville, Wythe County. The figures of production of mineral paints for 1911 and 1912 are combined with those of another subject.

LIST OF MINERAL PAINT PRODUCERS.

OPERATOR	OFFICE	MINE
Frazier Paint Co.	Detroit, Mich.	Bedford City
Hiwassee Chemical & Color Mines	Hiwassee	Hiwassee
Stigleman, W. T.	Snowville	Snowville
Virginia Ocher Corporation (a)	Irwin, Pa.	Stanleyton

aFormerly Page Ocher Corporation, Stanleyton.

MARL.

Greensand and shell marls are widely distributed over the Coastal Plain region of Virginia, but there was no reported production of either during

1911 and 1912. Shell marls in Isle of Wight County were dug and used by the Norfolk Portland Cement Corporation in the mix for the manufacture of Portland cement at their plant in Norfolk.

Fresh water calcareous marls of excellent grade and in quantity are found in several counties of the Valley region west of the Blue Ridge. Active preparations were in progress during 1912 in Bath and Rockingham counties to mine these marls for agricultural purposes.

PYRITE AND PYRRHOTITE.

Virginia has long held first position as a producer of pyrite among the pyrite-producing states in the United States. The production for the years 1911 and 1912 was from four operators as follows: Cabin Branch Mining Company's mine, near Dumfries, Prince William County; Arminius Chemical Company (Inc.) and Sulphur Mining and Railroad Company's mines, 1.5 and 4 miles, respectively, north of Mineral, Louisa County; and the Pulaski Mining Company's mine at Monarat, Carroll County. The ore mined by the Pulaski Mining Company at Monarat is chiefly pyrrhotite, which is utilized in their plant at Pulaski.

In addition to the producing properties in 1912 named above, one new property was being developed and plans for the reopening of several old ones were in progress. The Old Dominion Pyrite Mining Company began developing in 1912 a property located about 1 mile east of the Arminius mine and about 2 miles north of Mineral in Louisa County. Preparations were being made to reopen the Boyd Smith mine situated north of Mineral, between the mines of the Arminius Chemical Company and the Sulphur Mining and Railroad Company. The mine on Austin Run, near Stafford, Stafford County, developed by the Austin Run Mining Company was taken over by the Old Dominion Sulphur Company, for reopening and working.

The production of pyrite (concentrated and crude) in Virginia during 1912 amounted to 162,478 long tons, valued at $621,219, against 150,800 long tons, valued at $558,494 in 1911, an increase of 11,678 long tons in quantity and $62,725 in value. There was an increase in the average price per ton from $3.70 in 1911 to $3.82 in 1912. The average sulphur content in pyrite produced in Virginia during 1911 and 1912 was about 43 per cent.

There is given in the table below the production of pyrite in Virginia from 1908 to 1912, inclusive.

Production of Pyrite in Virginia, 1908-1912, inclusive.

Year	Quantity	Value	Average price per ton
1908	116,340	$435,522	$3.74
1909	114,176	423,283	3.71
1910	140,106	525,437	3.75
1911	150,800	558,494	3.70
1912	162,478	621,219	3.82

LIST OF PYRITE PRODUCERS.

OPERATOR	OFFICE	MINE
Arminius Chemical Co.	Mineral	Mineral
Cabin Branch Mining Co.	Baltimore, Md.	Dumfries
Pulaski Mining Co.	New York, N. Y.	Monarat
Sulphur Mining & Railroad Co.	Richmond	Mineral

ARSENIC.

The mines of the United States Arsenic Mines Company, located 14 miles southeast of Christiansburg, at Brinton, Floyd County, did not produce during 1911 and 1912. The ore is arsenopyrite, a sulph-arsenide of iron (FeAsS), and occurs in lenses in quartz-sericite schist.

RUTILE (Titanium).

Virginia is the only producer of rutile in the United States, and much of the product is shipped abroad. The American Rutile Company, operating at Roseland, Nelson County, was the only producer in 1911 and 1912. This company is mining and milling rutile in the hard rock syenite, and in 1912 added a magnetic separating machine to its equipment. The nelsonite occurrence of rutile in the same district is not now mined. There was no production of rutile in 1911 and 1912 from the recently exploited deposits of Goochland and Hanover counties in the central eastern portion of the Virginia Piedmont province.

The 1912 production was large and greatly in excess of that of any previous year.

MINERAL WATERS.

The production of mineral waters in Virginia during 1912 showed a marked increase in quantity and value over that of the previous year 1911. In 1912, the production of mineral waters was 2,762,319 gallons, valued at $349,255, as compared with 2,474,918 gallons, valued at $298,701 in 1911, an increase of 287,401 gallons in quantity, and $50,554 in value. These figures are exclusive of the quantity of water used in the manufacture

of soft drinks. The average price per gallon of the water sold in 1911 was 12 cents, and in 1912, 13 cents.

The following table gives the production and value of mineral waters in Virginia from 1908 to 1912, inclusive.

Production and value of Mineral Waters in Virginia, 1908 to 1912.

Year	Springs reporting sales	Quantity sold (Gallons)	Value
1908	46	2,009,614[a]	$207,115
1909	49	1,504,530[a]	203,455
1910	40	2,441,923[a]	301,523
1911	43	2,474,918[a]	298,701
1912	45	2,762,319[a]	349,255

aAmount used for soft drinks not included.

Of the 2,474,918 gallons of mineral waters sold in Virginia during 1911, valued at $298,701, $116,052 worth was sold for medicinal purposes and $182,649 worth for table or domestic use; and during 1912, of the $349,255 worth sold, $162,380 was for medicinal purposes, and $186,875 was for table or domestic use. The total number of springs reported as producing in 1911 was 43, and in 1912, 45. These were distributed among the following 24 counties: Alexandria, Amelia, Augusta, Bath, Botetourt, Chesterfield, Culpeper, Franklin, Henrico, Loudoun, Mecklenburg, Montgomery, Norfolk, Nottoway, Prince Edward, Princess Anne, Roanoke, Rockbridge, Rockingham, Surry, Sussex, Tazewell, Warwick, and Wythe.

Virginia occupied third place in 1911 and 1912 in the number of commercial springs in the United States, and also in the value of medicinal waters sold. As indicated above nearly one-half of the output is sold for medicinal use. Eleven springs reported resorts in 1912, accommodating 1,400 people, and at 6 the water is used for bathing. The returns show that about 91,000 gallons of water are used to make soft drinks, in addition to the sales.

Out of a total of 62 springs credited to Virginia, 43 reported sales in 1911, and 45 in 1912. The list of producing springs for the years 1911 and 1912 is as follows:

Alleghany Springs, Alleghany, Montgomery County.
Basic Spring, Basic City, Augusta County.
Bear Lithia Spring, near Elkton, Rockingham County.
Beaufont Spring, South Richmond, Chesterfield County.
Berry Hill Mineral Spring, Elkwood, Culpeper County.

Blue Ridge Springs, near Blue Ridge Springs, Botetourt County.
Bowman Spring, near Staunton, Augusta County.
Broad Rock Mineral Spring, near Richmond, Chesterfield County.
Brugh Spring, Nace, Botetourt County.
Buckhead Lithia Spring, Buckhead Springs, Chesterfield County.
Buffalo Lithia Spring, Buffalo Lithia Springs, Mecklenburg County.
Burnetts Spring, Hudson Mill, Culpeper County.
Campfield Lithia Well, Richmond, Chesterfield County.
Carper Lithia Springs, Radford, Montgomery County.
Como Lithia Spring, East Richmond, Henrico County.
Coppahaunk Mineral Springs, Waverly, Sussex County.
Crockett Arsenic Lithia Spring, Crockett Springs, Montgomery County.
Diamond Spring, Diamond Spring, Princess Anne County.
Erup Mineral Spring, near Glencarlyn, Alexandria County.
Farmville Lithia Springs, Farmville, Prince Edward County.
Fonticello Mineral Spring, near Manchester, Chesterfield County.
Harris Anti-Dyspeptic Spring, Burkeville, Nottoway County.
Healing Springs, Hot Springs, Bath County.
Iron-Lithia Springs, Tip Top, Tazewell County.
Jeffress Spring, Jeffress, Mecklenburg County.
Kayser Lithia Springs, Staunton, Augusta County.
Kiwassa Lithia Springs, near Manchester, Chesterfield County.
Landale Spring, near Ocean View, Norfolk County.
Lithia Magnesia Spring, Rocky Mount, Franklin County.
Magee Chlorinated Lithia Spring, Clarksville, Mecklenburg County.
Massanetta Spring, near Harrisonburg, Rockingham County.
Mecklenburg Mineral Spring, Chase City, Mecklenburg County.
Mico Well, Alexandria, Alexandria County.
Mulberry Island, Mulberry Island, Warwick County.
Nye Lithia Springs, Wytheville, Wythe County.
Otterburn Lithia Spring, near Amelia, Amelia County.
Pæonian Springs, Pæonian Springs, Loudoun County.
Pickett Spring, Worsham, Prince Edward County.
Roanoke Lithia Spring, Roanoke, Roanoke County.
Rockbridge Alum Springs, Rockbridge Alum Springs, Rockbridge County.
Rubino Healing Springs, Healing Springs, Bath County.
Seawright Spring, near Staunton, Augusta County.
Stribling Springs, Stribling Springs, Augusta County.
Tripho Mineral Spring, Claremont, Surry County.
Virginia Etna Spring, Vinton, Roanoke County.
Virginia Lithia (Lion Mineral), near Richmond.
Virginia Magnesian Alkaline Spring, near Staunton, Augusta County.
Wallawhatoola Springs, Millboro, Bath County.
Wyrick Mineral Spring, Crockett, Wythe County.

There are 49 springs listed above, three of which produced in 1911 that did not produce in 1912. These were Diamond Spring, Iron Lithia Spring, and Kiwassa Lithia Spring.

ZIRCONIFEROUS SANDSTONE NEAR ASHLAND, VIRGINIA[a]

BY THOMAS L. WATSON AND FRANK L. HESS.

INTRODUCTION.

In 1910, Mr. August Meyer, of Richmond, Virginia, submitted to one of the writers a specimen of rock obtained about three miles west of Ashland, which was thought to contain rutile. It was a fine-grained friable dark reddish-brown rock, in which grains of ilmenite or some similar black mineral were distinctly visible. The color of the other grains was apparently similar to that of the rutile found 10 to 15 miles farther southwest, in Hanover and Goochland counties, and under a hand lens no difference in appearance could be distinguished. As the rutile of these counties occurs with a very black ilmenite, it was thought that the specimen might possibly be a fine-grained mass of titanium minerals. Microscopic examination of a thin section, however, showed the rock to be a sandstone composed of very small grains of ilmenite and zircon (zirconium silicate, $ZrSiO_4$), together with a few grains of other minerals, chiefly quartz and silicates, cemented with limonite.

In June, 1911, the writers, in company with Mr. Meyer, visited the locality from which the latter obtained the original specimen, on the farm of Mr. F. B. Sheldon, 3 miles west of Ashland, Hanover County, and about 20 miles north of Richmond.

GENERAL GEOLOGY OF THE AREA.

The area of zirconiferous sandstone forms a part of the western edge of the Coastal Plain, near and along the overlap of the sediments upon the older crystalline rocks of the Piedmont Plateau (see map, fig. 1). Along this edge (the "fall-line") the surface is somewhat roughened from erosion, but to the east it becomes more gently rolling and is essentially flat and featureless. The area lies on the south side of South Anna River, but within its drainage basin and only a short distance southwest of its confluence with the North Anna to form Pamunkey River.

aBull. 530-P, U. S. Geol. Survey, 1912; also Bull. Phil. Soc., University of Virginia, Scientific Section, 1912, vol. i, No. 11, pp. 267-292.

The sandstone outcrops along a low ridge having gently sloping sides and a general direction of N. 20° E. At the point where the sandstone seems to be most abundant and perhaps richest in zircon the ridge marks

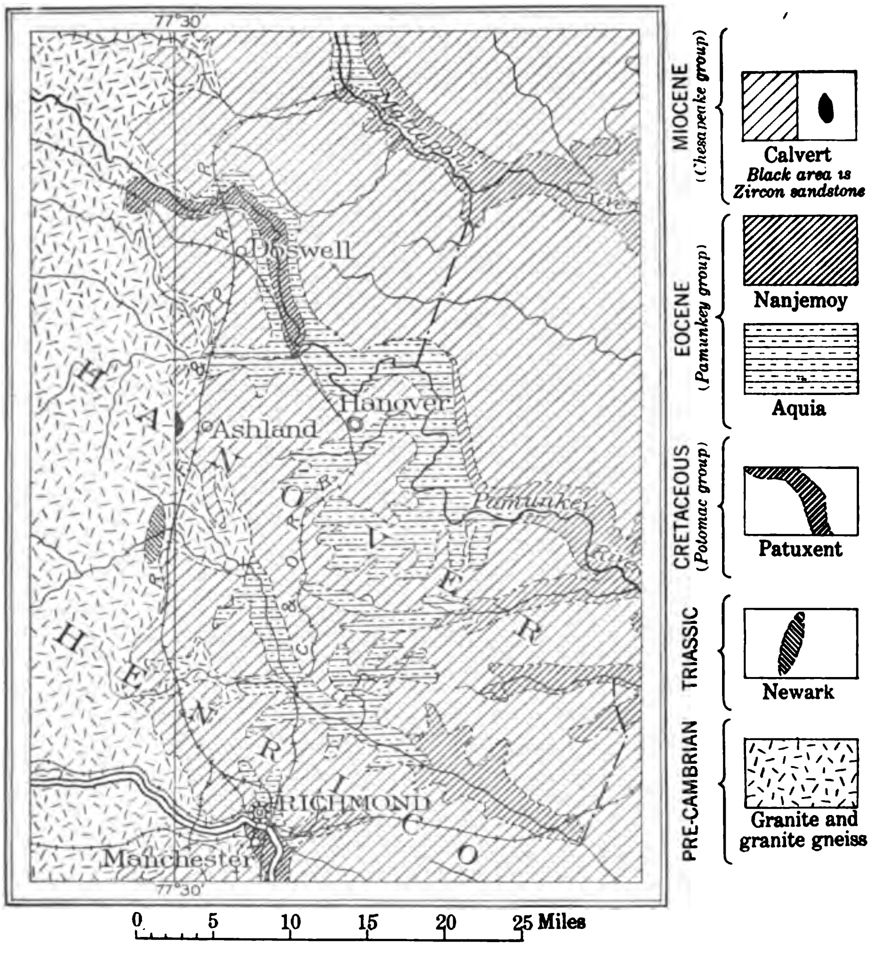

Fig. 2.—Geological map of a part of middle eastern Virginia, showing location of zirconiferous sandstone area west of Ashland, Hanover County. (Geological map of Virginia, Virginia Geological Survey, 1911.)

the western edge of the Calvert formation, the lowest formation of the Chesapeake group (Miocene). Within this area and for some distance north and as far south as a point 25 miles north of Petersburg the Calvert

formation transgresses the underlying older Coastal Plain sedimentary formations, and its western margin rests upon the crystalline rocks of the Piedmont Plateau.[a] The Calvert formation in Virginia is about 200 feet thick and consists chiefly of sands, clays, marls, and diatomaceous earth, fine-grained sands being predominant. Diatomaceous earth has not been identified in the Ashland area.

Extending westward from the foot of the west slope of the low ridge mentioned above are the crystalline rocks of the Piedmont Plateau, chiefly granites and gneisses, most of which are of pre-Cambrian age. The contact between the sedimentary formations of the Coastal Plain and the crystalline rocks of the Piedmont Plateau extends across the State in roughly a general north-south line and in position nearly coincides with the meridian 78° 30′.[b]

In the southern part of the State the Calvert formation is overlain by the St. Mary's formation (middle Miocene), and along the western edge the St. Mary's transgresses the Calvert and rests on the crystalline rocks of the Piedmont Plateau.

DISTRIBUTION AND OCCURRENCE OF THE SANDSTONE.

In the Ashland area the sandstone does not outcrop in a continuous bed. It was seen only in the form of irregular flat fragments lying loose upon the surface. The fragments are of the same reddish-brown to yellow color as the specimen submitted by Mr. Meyer. In size the fragments range from those as large as a man's fist to some measuring 2 feet long, 2 feet broad, and 6 inches thick. There is as much variation in texture as in size, and the rock accordingly ranges from a typical fine-grained sandstone to a typical moderately coarse conglomerate, with intermediate gradations. Much of it is very fine-grained, showing little visible quartz. Other pieces are of varying degrees of coarseness, some containing quartz and quartzite pebbles 2 inches in diameter. Some pieces show cross-bedded structure.

The largest number of the sandstone fragments were seen on a small mound 150 yards southwest of Mr. Sheldon's house, and scattered fragments can be found both to the north and the south for a distance of half a mile. On Mr. J. B. Davis's farm, which adjoins the Sheldon farm on the north, there are many pieces of the sandstone, though most of them are smaller. However, many of the pieces, especially those found farther north, are of lighter color and lower specific gravity than the fragments

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[a] Virginia Geol. Survey, Bull. No. IV, 1912, p. 126 *et seq.*

[b] See the geological map of Virginia, Virginia Geological Survey, Charlottesville, 1911.

from the Sheldon farm, though one of the richest specimens collected was from the line between the Thomas Kies and John Boschen farms, half a mile north of the Sheldon farm. The specific gravity is of value in field examination, for specimens having low specific gravity show only a few grains of zircon, whereas those having high specific gravity carry a large percentage of the mineral.

It is probable that the hard lumps of sandstone represent the local cementation of a sandy bed which, in most places, is soft or but slightly consolidated, a characteristic of the Chesapeake group (Miocene). Partly or wholly indurated sands, yielding somewhat highly ferruginous crusts and beds of sandstone, are common in the formations of the Virginia Coastal Plain near its western margin. So far as the authors are aware these ferruginous sandstones have been generally regarded as composed chiefly of quartz grains cemented by iron oxide. At no point beyond the Ashland area, so far as known, have they been tested for zircon or other uncommon heavy minerals.

At the home of Mr. Benjamin Wright, three-eighths of a mile southwest of Mr. Sheldon's house, a highly zirconiferous and but slightly consolidated sand bed was cut in the lower part of a well 14 feet deep. This bed is probably the same one from which the indurated or hardened fragments of zirconiferous sandstone have come. Perfectly rounded water-worn quartz and quartzite pebbles, mostly quartz, up to 3 inches in diameter and usually white in color, were taken from this well at a depth of 14 feet. None of the zirconiferous material was found south of Mr. Wright's well, and decomposed granite is exposed in a road 200 yards southwest of his house.

A hundred yards northwest of Mr. Sheldon's house a bed of zirconiferous sand, similar to that cut in the Wright well, was exposed in a shallow prospect hole. The zirconiferous sand was 18 inches thick and was underlain by clay and covered by a few inches of soil.

From the appearance of the float and the sand cut in the prospect hole, the zirconiferous bed is thought to be probably not more than 2 to 3 feet thick. The data at hand indicate that it is probably a narrow lens three-eighths of a mile long and of unknown but probably of less width.

TESTS.

The zircon was separated from six lump samples weighing from 50 to 100 grains each as follows: The lumps were first treated with hydrochloric acid to dissolve the cement of limonite. In two specimens small lumps

resisted dissolution and were treated with aqua regia on a steam bath for two days, which resulted in dissolving the cement and disintegrating the sand grains. After washing by decantation the sand was digested with a mixture of sulphuric and hydrochloric acids to remove ilmenite and quartz and then washed. The specimens thus treated yielded zircon as follows:

Zircon obtained from sandstone near Ashland, Virginia.

Locality	Gross weight of sample	Zircon	
	Grams	*Grams*	*Per cent*
Specimen from low hill, F. B. Sheldon's farm..	50	14,955	29.9
Specimen from low hill, F. B. Sheldon's farm..	100	25,375	25.4
Specimen from low hill, F. B. Sheldon's farm..	52	6,280	12.1
Specimen from 100 yards northwest of F. B. Sheldon's house	100	15,890	15.9
Specimen from Wright's well..................	52	6,815	13.1
Specimen from top of hill on line between Thomas Kies' and John Boschen's land.....	100	27,230	27.2
Total		96,545	

Accessory heavy minerals in the form of impurities, such as cyanite, garnet, and staurolite, could not be separated from the zircon by the method used, and the results given in the table above are perhaps 2 to 3 per cent too high, though certainly not more. Owing to possible losses through the severe treatment during separation and to the loss of fine zircon in decanting, the tests are as likely to show less as more than the quantity present. The results are not, of course, to be regarded as exact, but the method of selecting random specimens from float rock would not warrant more accurate determinations.

It is not thought that the method used in separating the material introduced appreciable errors, as a blank test run on finely pulverized zircon by treating it with a mixture of sulphuric and hydrofluoric acids, showed at the end of three days no trace of zircon in solution.

The zircon crystals in the material are minute, averaging less than 0.5 mm. in diameter. Out of about 96 grams of zircon separated, a small quantity was caught on a sieve of 60 meshes to the linear inch; possibly 1 per cent would not pass through a sieve of 80-mesh; nearly 17 per cent (16.23 grams) passed through an 80-mesh and was caught on a 100-mesh sieve; 77 per cent (74.15 grams) passed through a 100-mesh sieve and was caught on a 150-mesh sieve; and more than 2 per cent (2.3 grams) passed

Fig. 1.—Microphotograph of zircon separated from sandstone obtained 3 miles west of Ashland, Virginia. Passed through a 150-mesh sieve. Rounding of the grains from wear is shown, but in many cases the original crystal outline can be seen. Magnified 97 diameters.

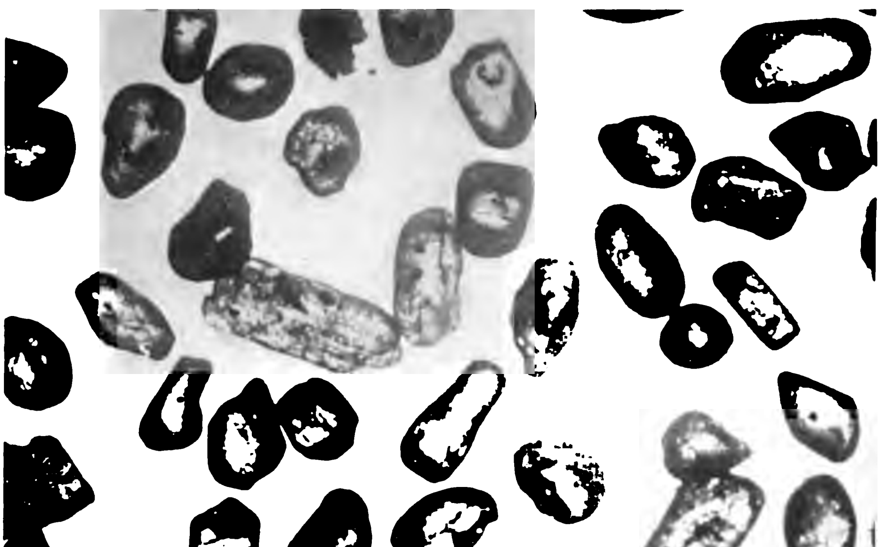

Fig. 2.—Microphotograph of zircon separated from sandstone obtained 3 miles west of Ashland, Virginia. Passed through an 80-mesh sieve and caught on a 100-mesh sieve. Rounding of the grains from wear is pronounced. Large prismatic grain to right of center is cyanite. Magnified 97 diameters.

MICROPHOTOGRAPHS OF ZIRCON SEPARATED FROM SANDSTONE.

through a 150-mesh sieve. Most of the accessory minerals (impurities) can be caught on an 80-mesh sieve.

CHARACTER OF THE SEPARATED ZIRCON CRYSTALS.

The zircon crystals, as separated above, are mostly of short, stout form, though they include a smaller number of elongated forms, possibly one and one-half times as long as thick. In mass they are pinkish or pinkish brown, but on heating to redness they become colorless. Under the microscope individual crystals are pink or yellow, but much the largest number are colorless. The crystals in most specimens are very much worn, but the crystals in the specimens from the prospect hole northwest of Mr. Sheldon's house show beautiful crystal form. Though nearly all of the zircon is undoubtedly worn, the wear in general may be in part apparent only, as small zircon crystals formed in place very commonly have outlines that do not show good faces or angles. The difference in the amount of wear of the particles which were caught on a 100-mesh sieve and of those which passed through a 150-mesh sieve is striking (see Pl. I, figs. 1 and 2). The greater mass of the larger crystals small as they are seems sufficient to cause much more fracturing from the force of impact when thrown around by waves and currents.

ASSOCIATED MINERALS.

Associated with the zircon are quartz and a variety of heavy minerals, including garnet (?), ilmenite, rutile, staurolite, cyanite, and an isotropic green mineral which has not been definitely determined but which may be pleonaste or hercynite. Occasional feldspar and pyrite were noted in several thin sections of the rock. As stated above, these are all cemented with limonite, possibly in part siliceous.

Ilmenite is the most abundant mineral in the rich pieces and its grains are of about the same size as those of zircon. The quartz and cyanite grains are generally several times as large. In places the fine-grained zircon and ilmenite surround quartz pebbles an inch long with the other dimensions somewhat smaller.

No magnetite was found in the material.

MICROSCOPICAL PETROGRAPHY.

The petrography of the rock is simple, but the general character of the minerals and their relations to one another and to the cement are more

definitely established by microscopic than by megascopic study. Considered as to mineral composition the ten thin sections of the rock studied may be divided into two groups, (1) zircon-ilmenite sandstone and (2) quartz sandstone. The rounding of the ilmenite and zircon grains is pronounced, but the quartz sand is remarkably angular[a] (see Pls. I and II). Both are cemented more or less firmly by oxide of iron, chiefly limonite and probably a less hydrous oxide of reddish color, possibly göthite or hematite.

Of the minerals present in the sandstone, zircon, ilmenite, and quartz are the three most abundant, and are described below in the order named. Occasional grains of an unstriated feldspar were noted in one or two of the quartz-rich sections, and red- to yellowish-brown rutile in partially rounded grains of variable size is sometimes present, always in association with ilmenite. Ferromagnesian minerals are entirely absent.

Zircon.

In the thin sections the zircon is mostly colorless, though occasional light yellow and pinkish crystals were observed, and is readily identified by its high refraction and double refraction. The grains usually show rounded outline and many of them are nearly spherical. They range from approximately equidimensional to elongate forms, and the angles or corners of those that exhibit squarish to rectangular cross-sections usually show more or less rounding (Pls. I and II). Crystal outline is frequently observed but as a rule it is modified by rounding from wear. Zircon grains separated from the rock and examined under the microscope usually show rounding from wear and rather dull luster (Pl. I, figs. 1 and 2). The most perfectly rounded grains are apt to exhibit the least luster. The zircon grains average from 0.2 to 0.3 mm. in diameter. Some of the larger elongated grains measure as much as 1.1 mm. in the direction of elongation. Some grains show cleavage and many indeterminable inclusions.

A fairly noticeable feature in many of the zircon grains is an apparent irregular, thin, cloudy and light-colored peripheral zone or border, which appears isotropic or but feebly double refracting. This border probably represents the pitted surface made by pounding against other fragments and possibly to some alteration from hydration.

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[a]This is in accordance with the investigation of Mackie on the rounding of sand grains, who observed that grains of zircon were rounded more readily than those of quartz, due possibly to the greater density of the zircon. See Mackie, Wm., Trans. Edinburgh Geol. Soc., 1897, vol. vii, pp. 298-311.

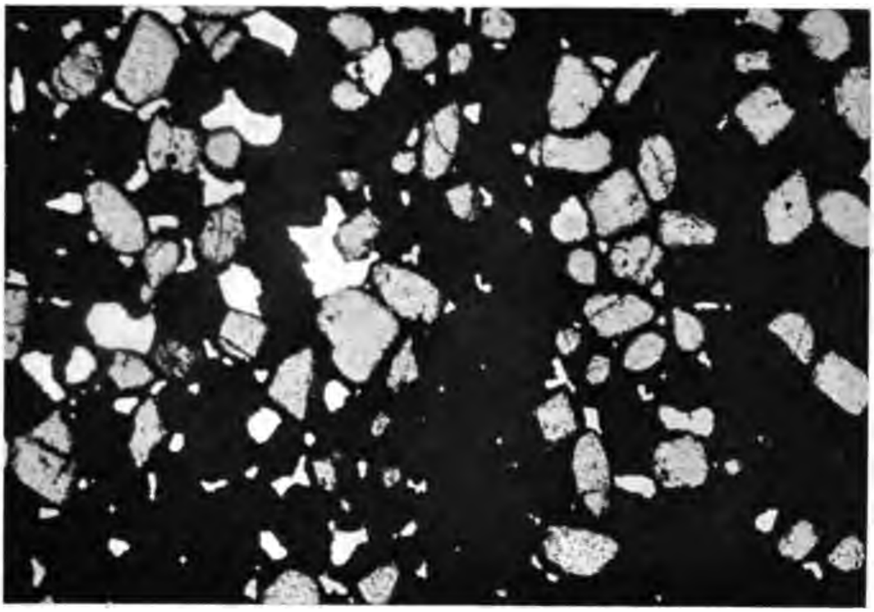

Fig. 1.—Microphotograph of a thin section of zirconiferous sandstone obtained 3 miles west of Ashland, Virginia. The grains of high relief showing rounding from wear are zircon; the smaller, angular, white grains are quartz; and the black groundmass is mostly ilmenite; the whole is cemented with limonite. Magnified 97 diameters.

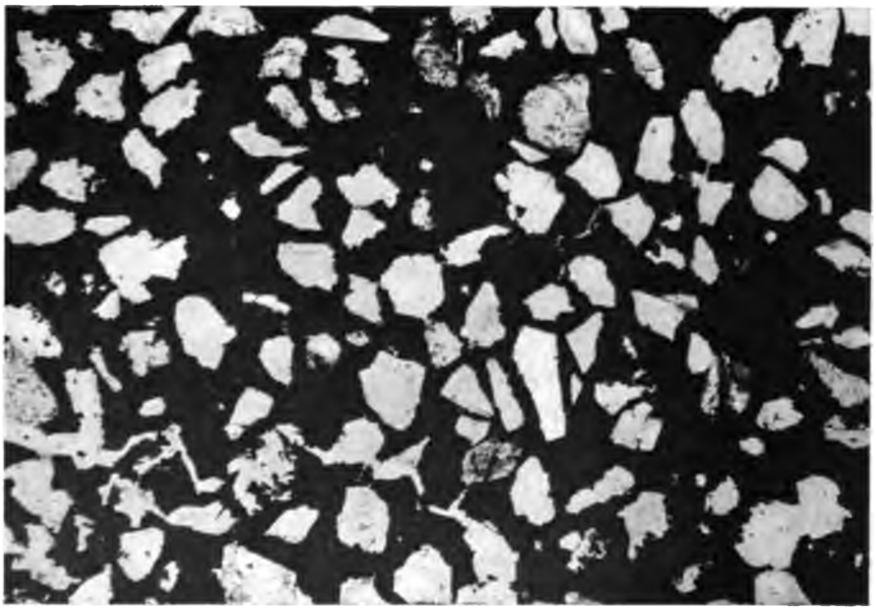

Fig. 2.—Microphotograph of a thin section of zircon-bearing sandstone obtained 3 miles west of Ashland, Virginia. The white, angular grains are mostly quartz with a few of feldspar; the scattered, roundish grains of high relief are zircon, and the black groundmass is mostly limonite, which forms the cement, with some grains of ilmenite. Magnified 97 diameters.

MICROPHOTOGRAPHS OF ZIRCONIFEROUS SANDSTONE.

Ilmenite.

Ilmenite is most abundant in the zircon-rich thin sections. It exceeds zircon in amount and is least in quantity in the quartz-rich sections, and almost absent from some. It is remarkably fresh, in grains of about the same size as the zircon grains, probably most of them a fraction larger, and of irregular though somewhat rounded outline.

Quartz.

Quartz is present in every thin section but varies greatly in amount, from occasional grains in the zircon-ilmenite-rich rock to the dominant and vastly the most abundant mineral in the quartz-rich rock. It is likewise subject to much variation in size and shape of grain. The grains generally range between 0.2 and 1 mm. in diameter, though smaller and larger ones were noted, and in contrast to zircon and ilmenite are mostly angular in outline. Well-rounded grains are not numerous.

The quartz grains are of granitic character and some contain abundant liquid and solid inclusions. Many of them show pronounced strain shadows as the result of dynamic forces to which the original rock from which they were derived was subjected. The quartz grains in the same thin section will usually average larger in size and more angular in outline than the zircon. The general character of the quartz grains is shown in Plate II, figure 2.

Cement.

In hand specimens the cement is a decided reddish-brown color. In thin sections it is opaque and generally brown in reflected light, and occasionally transparent and deep red in transmitted light. It is sharply differentiated from the mineral grains, which are remarkably fresh. No gradation from the iron-bearing mineral grains into the cement was observed, such as would be expected if the cement were derived by alteration of those iron-bearing minerals present in the rock.

GENESIS.

The zircon and ilmenite concentration evidently represents an old beach segregation along but within the western margin of the Miocene sediments of the Coastal Plain, of probably Calvert age, and is similar to the black-sand beaches of New Jersey, California, Oregon, New Zealand, New South Wales, and numerous other coasts, and to the gold-bearing garnet (so-called "ruby") sands of the beaches at Nome, Alaska (see fig. 3).

The zircon and other heavy minerals resistant to atmospheric agencies were derived by weathering processes from the crystalline rocks, chiefly

granites and gneisses, of the Piedmont Plateau, which extend westward from the Coastal Plain contact. These formed the country rock of the shore, and the zircon and associated minerals derived from them by weathering were accumulated by waters near the mouth of a small stream or behind a sheltered point, while the quartz sand was largely worn and carried away by the currents of the sea.

Zircon is an almost constant minor accessory mineral in the crystalline rocks, especially granites and gneisses, of this old shore and its extension westward, and in places it occurs in large masses. Thin sections of granites occurring immediately west of Ashland and at other places in the Piedmont Plateau of Virginia show the presence of zircon, chiefly as inclusions in the quartz and feldspar. Near Gouldin post-office, 10 to 15 miles southwest of the Ashland area, pieces of zircon 3 inches in diameter weathered out of pegmatite dikes have been noted on the surface. Massive zircon without crystal outline, measuring 4 by 6 inches, has been observed in the pegmatites of Amelia County, Virginia. Similar dikes occur in the gneiss-granite complex of the Piedmont Plateau, forming the old shore-line which extends entirely across Virginia from Maryland into North Carolina, roughly coinciding with the meridian of 77° 30″. The zircon in the sandstone was not derived, however, from the pegmatites in which it occurs in comparatively large masses, but from the granites and gneisses which carry it

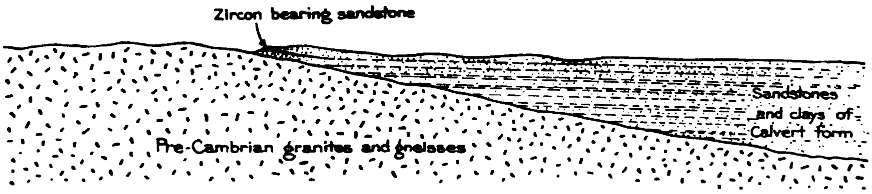

Fig. 3.—Generalized east-west section across the fall-line near Ashland, Virginia, illustrating the occurrence of zircon-bearing sandstone.

in innumerable very small crystals. It seems probable that similar zircon-rich sandstones may occur at numerous points along this old shore-line. Many zircon-bearing deposits may be covered by later sediments and some may have been removed by erosion, but it is probable that others, which may be richer or poorer, will be discovered along the contact of the granite and gneiss of the Piedmont Plateau with the overlying sediments of the Coastal Plain.

It is probable that some magnetite was present with the ilmenite, and glauconite is abundant at places in the Calvert formation. The alteration of either of these minerals might produce limonite, which forms the cementing material. An occasional pyrite grain was observed in one or

two thin sections, and some hand specimens of the rock exhibit cavities which suggest the removal by decay of some previously existing mineral. From microscopic study of thin sections of the rock, it seems more probable, however, that the principal source of the cement was chemical precipitation from iron-bearing waters that percolated or filtered through the sand deposit.

ECONOMIC ASPECTS.

The uses of zircon enumerated below are largely suggested rather than actual and their practicability is mostly dependent on the cheapness of the zirconia and the quantity available. Böhm[a] states that large quantities of native zirconia (zirconium oxide) known as baddeleyite are found near Sao Paulo, Brazil, and that much has been shipped to Germany. This material, at the time he wrote, was being furnished at the following prices:

Composition and prices of baddeleyite.

Designation	ZrO_2	Fe_2O_3	SiO_2	Price per ton (2000 pounds)
	Per cent	*Per cent*	*Per cent*	
Zircon-S-Erz	90-92	1.	8	$151
Zircon-Z-Erz	90-92	7	1	155
Zircon-NS-Erz	98	0.8	1[a]	215

aRemainder H_2O.

The mineral quoted is in the form of oxide and for most purposes would be more desirable than zircon, which would have to be reduced to the oxide, and should sufficient native oxide be found to supply demands, competition would be difficult for zircon. For ferrozirconium or zirconium carbide the zircon could possibly be used without reduction to the oxide.

Should the demand for zircon and further testing of the Ashland deposit warrant exploitation, operations could be carried on with comparative ease. The rock crushes easily; the zircon and associated heavy minerals could be separated from the quartz by shaking tables, and the ilmenite could be picked out by a magnetic separator.

The demand for zircon is now small but, with the probable increased use of zirconia (ZrO_2), it will likely soon become greater.

Böhm[b] sums up the known and probable uses for zirconium substantially as follows:

aBöhm, C. R., Die Technische Verwendung der Zirconerde, Chem. Zeitung, Jahr 35. November 14, 1911, pp. 1261-1262.
bBöhm, C. R. Op. cit., pp. 1261-1262.

USES.

Zirconia (ZrO_2) has been used in place of lime and magnesia as the incandescing material in the oxy-hydrogen blowpipe, and a very small quantity of zirconium nitrate is used in making mantles for gas lights. Large quantities of zirconia were once used in the Nernst lamps, a form of incandescent electric lamp in which a small stick of zirconia and yttria is used as a glower, but its consumption is not now so large, owing to the competition of metallic filament lamps. Zirconium carbide has been used in making incandescent electric lamps, but this also has been superseded by metallic filament lamps. The property of incandescence possessed by zirconia has tempted arc-lamp manufacturers to use it in their electrodes, but thus far it has not been used successfully. Zirconia is an excellent insulator for both electricity and heat and when mixed with a conductor can be used for electric heaters. In the Heraeus iridium furnace the iridium may be protected by a glaze made from a zirconium salt in place of the thorium or yttrium salts now used. Zirconia makes an excellent and very refractory crucible, which is manufactured in many sizes by a German firm. Its refractoriness makes zirconia a suitable lining for electric furnaces, and Böhm suggests that it might be used for saggers, but for the ceramic trade it must be free from iron and cheap. He also suggests its use for the walls of furnaces, for the making of molds to withstand high temperatures, and for heat insulation. Owing to its inertness zirconia is suitable for chemical ware, and many forms are manufactured from it. The same property has led to its recommendation for certain medicinal uses, and in Röntgen ray therapy it is used in place of bismuth nitrate, which has sometimes given bad effects. Zirconia is a beautiful soft white powder which is well adapted for making paints and lacquers, as it is unaffected by gases, acids, or alkalies, and has good covering power. It makes a good opaque glass, but for this use the borate is better than the oxide. It is used for a polishing powder in place of tin oxide. Ferrozirconium is manufactured by one German firm for use in steel. Zirconium carbide is extremely hard and makes a valuable abrasive. Glass 7 mm. (¼-inch) thick is cut with it as readily as with a diamond.

Clear zircons of brownish, orange, or reddish color are cut for gems and are then known as hyacinths. There is no probability of stones sufficiently large for cutting being found at the Ashland locality, but they may be present in some of the pegmatites of the crystalline area.

GEOLOGY OF THE SALT AND GYPSUM DEPOSITS OF SOUTHWESTERN VIRGINIA[a]

BY GEORGE W. STOSE.

LOCATION.

Large deposits of salt and gypsum are known to occur along a belt of country 20 miles long running northeastward from the village of Plasterco, Va., and lying in Washington and Smyth counties. Much of this territory is in or near the valley of the North Fork of Holston River, and this

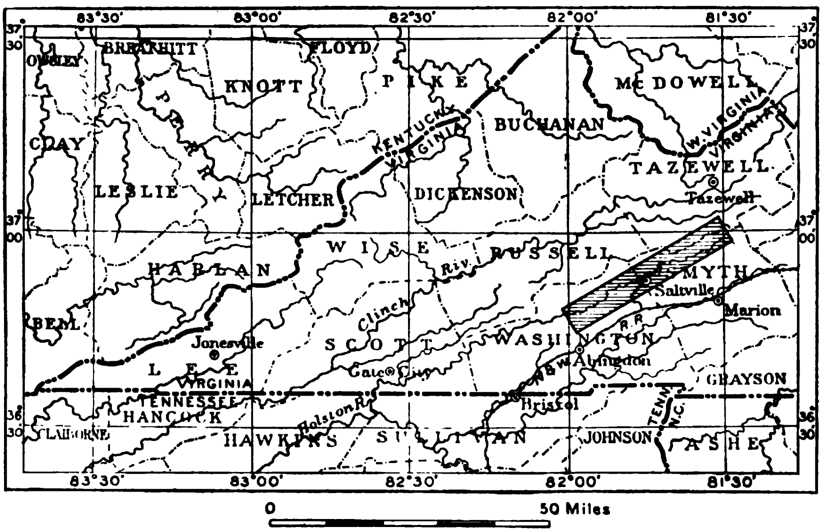

Fig. 4.—Index map of southwestern Virginia. The area described and mapped in this report is indicated by the shaded rectangle. Railroad connections for this area only are shown.

portion is made accessible to railroad transportation by the Saltville branch of the Norfolk & Western Railway, which joins the main line at Glade Spring. The location and relations of this area are shown in figure 4. Two gypsum plants and one salt or alkali works are now in operation in

[a]Republished with revision from Contributions to Economic Geology, 1911, U. S. Geological Survey Bull. 530, Part I.

this area. Numerous old gypsum workings and prospects indicate the extent of the deposits, some of which are at present not commercially workable because of lack of transportation facilities. The active mines, old workings, and prospects are shown on the geologic map in figure 5.

TOPOGRAPHY.

The area represented on the accompanying map (fig. 5) comprises a mountain ridge 1,000 feet high separating parallel valleys and rising above an adjacent deeply dissected plateau. The ridge, named Pine Mountain at the southwest and Brushy Mountain at the northeast, trends in a general N. 70° E. direction and its elevation ranges from 2,500 to 3,000 feet. It is cut nearly at right angles by several deep water gaps through which pass the waters from Clinch Mountain that drain into the North Fork of Holston River. This stream flows southwestward, in general hugging the foot of Pine Mountain, and its valley descends from an altitude of 2,000 feet at the northeast to 1,500 feet in the southwestern part of the area. The plateau to the southeast ranges from 2,000 to 2,500 feet in altitude and its surface is dissected into narrow transverse ridges and rounded hills.

GEOLOGY.

Stratigraphy.

The rocks in which the deposits occur are of Mississippian ("Lower Carboniferous") age. A generalized section of the Carboniferous rocks derived from several detailed sections in the vicinity of the mines is as follows:

Generalized section of Carboniferous rocks in the vicinity of Saltville, Va.

Newman limestone:	Feet.
Hard argillaceous limestone or calcareous shale, with a few beds of crystalline limestone	400+
Red calcareous sandstone and coarse crinoidal limestone, with some beds of argillaceous limestone	75
Light-blue to gray argillaceous, shaly limestone and calcareous shale, with a few thicker fossiliferous limestones	1,150
Largely thick even-grained blue fossiliferous limestone, with some beds of crystalline fossiliferous limestone	250
	1,875+

Maccrady formation:	Feet.
Earthy limestone and shale, dark gray, weathering lighter and crumbly, abundantly fossiliferous	225
Gray sandstone, mostly calcareous and crumbly, and shaly argillaceous or earthy limestone; fossiliferous at the top	120
Soft rocks, including shaly limestone and probably earthy sandstone and red shale, largely concealed	300
Upper part red shale and shaly sandstone, with some gray shaly sandstone; lower part soft light-buff shale, with thin black carbonaceous shale and coal seamlets, containing Mississippian plants	120
	765

Price sandstone:	Feet.
Hard irregular-bedded rusty-gray sandstone, with some heavier beds	95
Largely shaly sandstone, with a few harder beds	275
Massive gray to reddish-gray sandstone, thin bedded toward top, and fine conglomerate with scattered white quartz pebbles generally at base	50
	420

Devonian rocks:

Thin-bedded sandstone and sandy shale containing brachiopods of Chemung age.

Platy sandstone and slaty shale.

The Price sandstone is a hard ridge-making rock which forms the ridge known as Pine Mountain and Brushy Mountain. The southeastern face of this ridge is a dip slope of the hard rocks of this formation, which dip about 40° SE. The severed edges of the dipping strata are finely exposed in the gaps through the mountain and make picturesque ledges and cliffs. Less well exposed in the gaps and on the northwest slope of the ridge are the underlying shaly sandstones and shales which are sparingly fossiliferous and of Chemung age. The lithologic character of the Price sandstone, its general stratigraphic position, and the presence of coal seamlets near its top, indicate its equivalence to the Pocono, at the base of the Carboniferous system, and the invertebrate fossils obtained from it corroborate this opinion. In the adjacent region to the northeast the Price sandstone contains thick coal beds whose flora establishes its Mississippian age.

The Maccrady formation is composed of materials relatively so soft and easily disintegrated that it is deeply eroded and in general poorly exposed. It outcrops in the valley of the North Fork of the Holston but is largely covered by the terrace and flood-plain deposits of that stream.

The basal black shale and reddish sandy beds are not uncommonly exposed in the lower spurs of Pine Mountain, but the earthy limestones and shales of the formation are seen in few places. A few fossils have been found in some of the thin calcareous beds, and certain dark shales near the middle are in places highly fossiliferous. At the base are coal seamlets and underclays that carry plant remains. The invertebrates have been assigned by George H. Girty to the upper Mississippian, and he correlates the formation with the Moorefield shale of Arkansas. It also probably represents the lower part of the Mauch Chunk of Pennsylvania. In places plastic red and olive to bluish clays with gypsum deposits occur in the midst of the Maccrady formation. Their occurrence and relations are discussed under the heading "Origin of the Deposits," on pages 64-73. This formation has been called the Pulaski shale in geologic reports describing adjacent areas to the northeast, and this name would be used here were it not that Pulaski has a prior established usage for an Ordovician formation in New York. The new name Maccrady is here given to the formation, from the village of that name on the North Fork of Holston River, where the best section of the formation was measured.

The Newman limestone is calcareous throughout but contains shaly portions which weather readily to clay and soil. The limestone generally makes hills, which in most places assume rounded forms due to dissection by streams flowing across the trend of the beds into the larger longitudinal streams. The formation is highly fossiliferous and the fauna indicates its general equivalence with the Greenbrier limestone of West Virginia and Pennsylvania and the Batesville sandstone of Arkansas.

Pre-Carboniferous rocks are present in two tracts within the area presented on the map (fig. 5). Beneath the basal Carboniferous sandstone lie Devonian sediments, mostly shales and sandstones, about 2,700 feet thick, underlain in turn by Silurian sediments, also mostly shales and sandstones. These are not differentiated on the map, as they do not concern the problems here discussed. These rocks occupy the northwestern portion of the mapped area and form the slopes of Clinch Mountain, which is capped by the basal Silurian formation, the Clinch sandstone, of Medina age.

In the southeastern part of the area mapped are Cambrian strata, mostly hard gray to blue magnesian limestone and dolomite, which are also undifferentiated on the map. The oldest of these Cambrian rocks are adjacent to the Carboniferous, with successively younger beds to the southeast.

Structure.

The Cambrian rocks on the southeast are part of a great overthrust mass which rode on a flat fault plane over the Carboniferous strata on the northwest, as shown in the structure sections in figures 6 and 7. The Cambrian strata dip rather uniformly 30°-40° SE., successively older Cambrian strata appearing at the northwest. Massive gray dolomite and magnesian limestone of Cambrian age are adjacent to the fault throughout most of its course in the mapped area and probably form the competent strata that carried the thrust. There is no indication of an anticlinal axis in these lower limestones southwest of Saltville, where this formation has a narrow outcrop, but northeast of Saltville there is close folding in the broad belt of this formation adjacent to the fault, with all dips overturned to the southeast. A still lower Cambrian formation of red argillaceous shale and sandstone is exposed over part of this area. This folded portion of the Cambrian may represent the axis of an overturned anticline, the breaking and overthrusting of which initiated the faulting. This is no local or minor fault, however, for it has been traced throughout the southern Appalachians into the Rome fault, which has been demonstrated to have a horizontal displacement of at least 5 miles in the vicinity of Rome, Ga. A thrust fault of such magnitude and length must have a deep-seated origin and its plane may be a shear plane cutting diagonally across the strata, without folding except that produced by friction or drag.

The fault plane is exposed at several places in the area, dipping southeast, and its inclination varies from 20° to 60°. Figure 8 is a sketch of the faulted rocks in the cliff southwest of Maccrady. Next to the fault plane the dolomite of the overthrust mass is hardened and the bedding obliterated, and the vertical beds farther from the plane of movement are jointed parallel to the plane. The softer shaly limestones beneath are mashed and altered by circulating waters to clay adjacent to the fault.

Another section of the fault laid bare by old gypsum workings 2 miles east of Broad Ford shows the Cambrian dolomite resting on red and green clay containing gypsum, with 1 foot of black banded carbonized calcareous clay gouge directly beneath the fault plane, which dips 20°-40° SE. In places a dolomite breccia of large and small masses marks the fault contact. In the railroad cut at Plasterco the cemented breccia is freshly exposed and its components are seen to be largely dolomite, with minor fragments of chert, limestone, and shale.

Opposite Maccrady Gap a mass of Clinch sandstone of Silurian age and associated rocks of sufficient size to make a hill 250 feet high and nearly 1 mile long was caught up along the fault and is shown on the map (fig. 5) by the fault dividing west of North Holston.

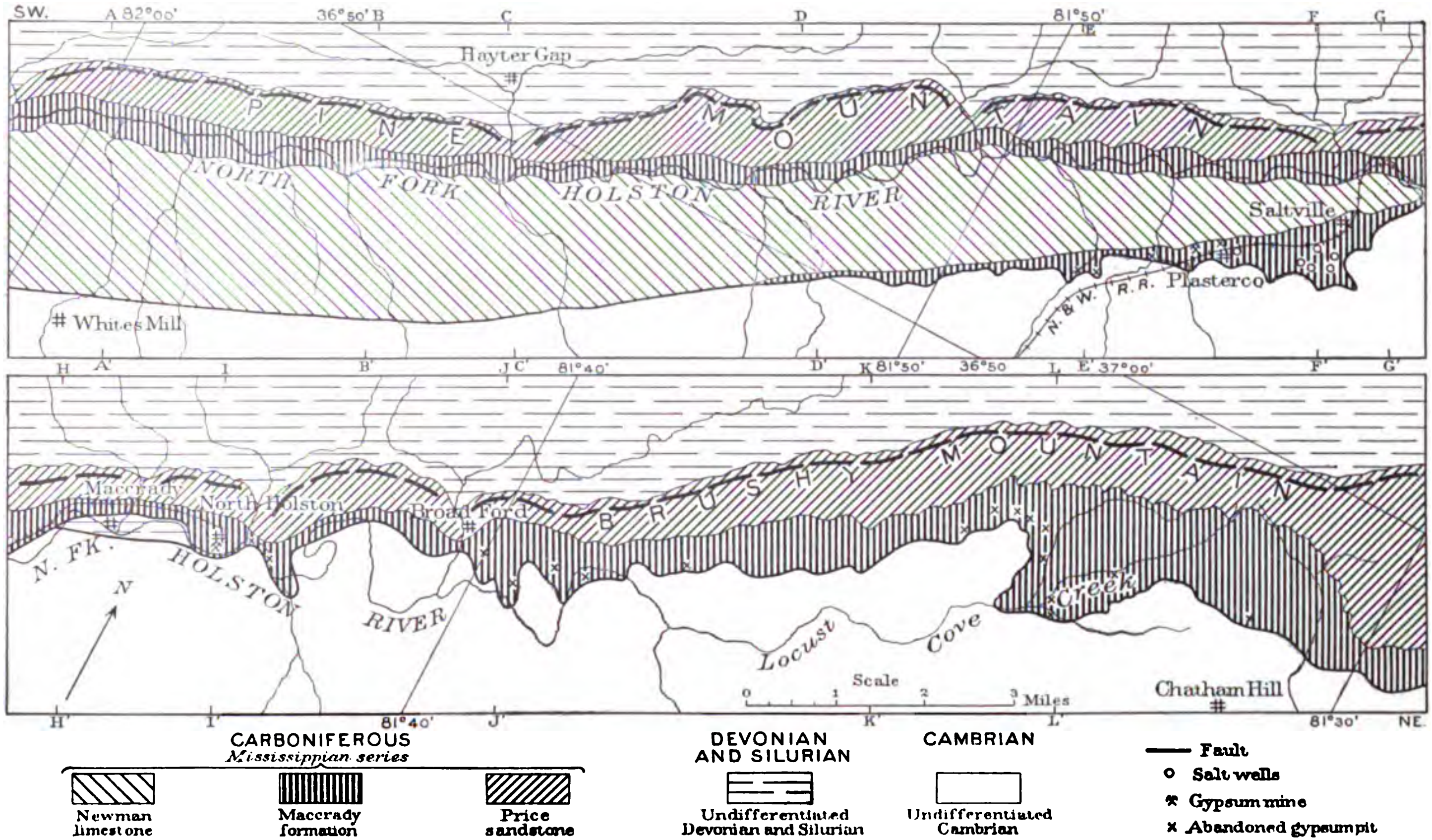

Fig. 5.—Geologic map of Holston Valley in the vicinity of Saltville, Va. The crest of Pine and Brushy mountains is represented by a heavy broken line. Letters on margins indicate lines of sections in figures 6 and 7.

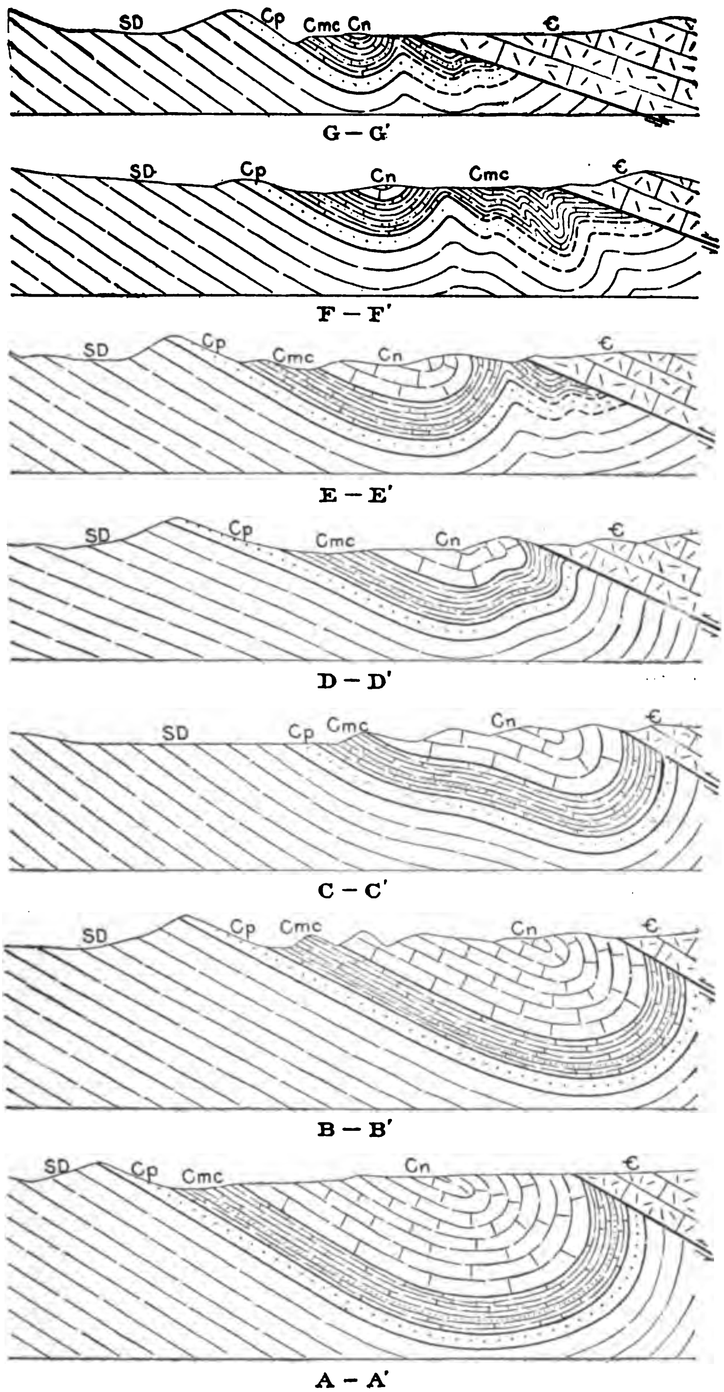

Fig. 6.—Structure sections across Holston Valley along lines indicated by letters on the margins of the geologic map (fig. 5). Cn, Newman limestone; Cmc, Maccrady formation; Cp, Price sandstone; SD, undifferentiated Devonian and Silurian rocks; Є, undifferentiated Cambrian rocks, mostly dolomite. Scale, double the scale of figure 5.

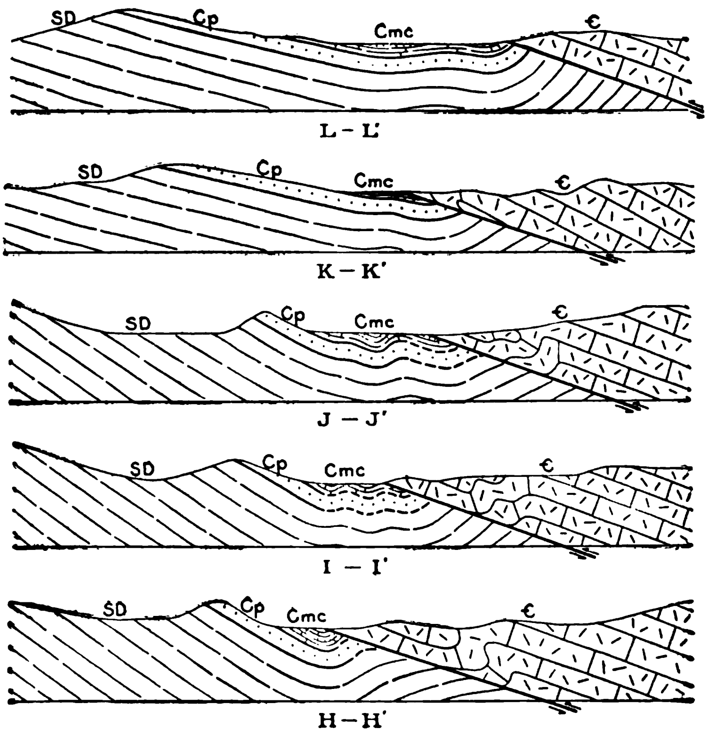

Fig. 7.—Structure sections across Holston Valley along lines indicated by letters on the margins of the geologic map (fig. 5). Cn, Newman limestone; Cmc, Maccrady formation; Cp, Price sandstone; SD, undifferentiated Devonian and Silurian rocks; Є, undifferentiated Cambrian rocks, mostly dolomite. Scale, double the scale of figure 5.

The outcrop of the fault plane is very crooked in the northeastern part of the area, owing to the facts that the plane is very flat in most places and is probably somewhat folded or wavy along the strike. Where the fault lies between the Cambrian dolomite and the shale of the Maccrady formation, it affords favorable channels for circulating underground water, from which springs issue at many places, and large solution channels are formed that may have aided in breaking down and removing the overlying dolomite at their outlets along the fault and may have assisted the formation of deep reëntrants in the trace of the plane. These reëntrants are invariably underlain by soft clays of the Maccrady formation, which form low flats generally without rock exposures. The reëntrant at Saltville is one of the largest, and is entirely barren of rock exposures. Another reëntrant is at Broad Ford, where there are only a few outcrops of the lower harder beds in the Maccrady. Northwest of Chatham Hill is a still larger reëntrant, due to the flattening of the general structure and a corresponding wider exposure of the softer rocks after being stripped of the overthrust Cambrian dolomite. These reëntrant areas are the chief places where salt and gypsum deposits have been found and are of especial interest in the study of the distribution and origin of these products.

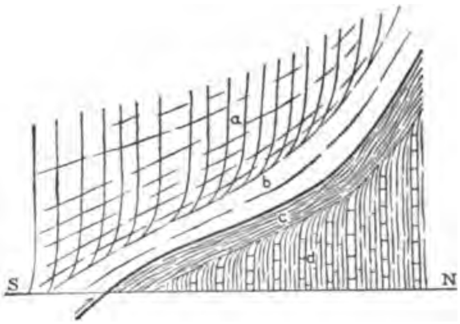

Fig. 8.—Section of the faulted rocks in the cliff southwest of Maccrady, Va. a, Massive Cambrian dolomite, bedding vertical but indistinct, jointing parallel to fault; b, zone of altered dolomite, bedding entirely obliterated; c, zone of altered and crushed argillaceous material, banded parallel to the fault; d, earthy limestone and calcareous shale (Carboniferous).

The rocks northwest of the fault, except those immediately adjacent to it, lie in a monocline, dipping 25°-40° SE., which culminates in Clinch Mountain, northwest of the area mapped. The soft Carboniferous rocks near the fault are bent into an overturned syncline. The sections in figures 6 and 7 illustrate the progressive rise in this syncline from southwest to northeast. As the Newman limestone rises northward in the shallowing syncline, erosion has removed its upper portion and its remnant gradually diminishes in thickness from 3,300 feet in the most southern section until northeast of Saltville it is entirely absent. The

soft underlying Maccrady formation does not extend all the way along the southeast side of the syncline, but is faulted out in the southwestern part of the area. Where present on the southeast side it is vertical or overturned.

No outcrops are visible in the broad flat at Saltville, but the absence of hard outcropping strata and the record of only soft rocks of Maccrady type in the deep wells at this place indicate that the syncline is followed on the east by an anticline whose east limb carries the Price sandstone below the points reached by the drill but apparently not deep enough to bring the Newman limestone down to the surface, so on the sections the rocks are shown to be undulating in the portions under cover of the overthrust fault.

Northeast of Saltville the beds of the Maccrady formation are so poorly exposed that their attitude is not generally shown. At the cliff west of Maccrady the last clear exposure of the syncline is preserved in the ledges of shale and sandstone. Just east of North Holston a small anticlinal roll of thin limestone in the Maccrady is an indication of the undulations probably existing throughout this band of soft rocks. East of Broad Ford a similar gentle fold is exposed in the small stream gully crossing the lowland.

Farther northeast the structure flattens more and more, and in the reëntrant northwest of Chatham Hill a thin limestone in the Maccrady formation indicates a very gentle syncline, followed on the southeast by a gentle anticline and another syncline, which is sharply turned up at the fault. The gentle syncline is also shown in the southward swing of the Price sandstone outcrops forming Brushy Mountain at the northeast end of the area mapped.

From the overturned syncline of Newman limestone at the southwest it might at first be concluded that this was a syncline associated with an overturned anticline on the southeast, which broke and was thrust over upon the syncline. However, it is concluded from a wider study of the structure that the fault did not originate in a broken fold but is of deeper-seated origin, being manifest by a shear plane cutting diagonally across the strata and folding and crumpling those at the overridden contact by reason of friction and drag.

SALT AND GYPSUM INDUSTRIES.

Salt.

Salt seepages were known to exist in the vicinity of Saltville in pioneer days, for this swampy flat was one of the salt licks frequented by wild animals and was sought by hunters and trappers and before them by the Indians. The early settlers dug shallow wells and extracted the salt from the brine that flowed from the springs. As early as 1836 two wells were reported in operation. During the Civil War the wells at Saltville were the main source of salt for the Confederacy. A brief history of the salt and gypsum industries of this region is given by T. L. Watson, Mineral Resources of Virginia.[a]

Present development.—The salt industry is now conducted by the Mathieson Alkali Works, with offices at Saltville. The Saltville Valley and surrounding country are owned and controlled by the company.

Since 1895, when the Mathieson Co. came into control of the property, the brine has not been evaporated into salt, but is converted by a modified and improved ammonia-soda process into soda products, chiefly sodium bicarbonate, or baking soda, which is the basis of all baking powders and is used also to some extent in making soda water. A large part of the production is in the form of soda ash, used extensively in the manufacture of glass, pottery, etc. Sal soda is also made for this purpose. Caustic soda, put up in large hermetically sealed cans, is prepared for medicinal and other purposes.

Over 50 wells have been drilled in the vicinity of Saltville, about 25 of which are at present in operation. They range in depth from a few hundred feet to 2,280 feet, the average being about 1,000 feet. The shallower wells are on the northwest side of the flat and the deeper ones on the southeast side, near the fault. The former are dry wells and have to be flushed with water through the outer casing. The wells on the southeast side are wet and the brine flows in as fast as it is pumped out. In the wet wells the rocks become honeycombed and cave in, in some wells bending the pipe so as to cripple or entirely disable the well. The brine is raised by ordinary deep pumps each operated by a walking beam driven by an electric motor housed in a small shack at the well, and the brine is piped to an open reservoir in the town. From the reservoir it is piped to the company's plant covering several acres on the east bank

[a] Watson, T. L., Mineral Resources of Virginia, Jamestown Exposition Com., 1907, pp. 211-213.

of the North Fork of Holston River, about a mile distant, where it is converted into baking soda and the other sodium products.

For the conversion of salt to these compounds large quantities of pure calcium carbonate are used, and an aerial bucket tram carries crushed limestone from the company's quarry 3 miles southeast across the limestone hills. As the limestone must be free from magnesium and other impurities, satisfactory rock is difficult to obtain in quantity. Part of the present supply comes from quarries at Marion, Va., about 25 miles distant by rail on the main line of the Norfolk & Western Railway. About 600 tons is used daily.

Gypsum.

Gypsum has been used for fertilizer for many years, and as early as 1835 the great possibilities of this deposit as a source of supply for the agricultural lands of Virginia were recognized. Over a decade ago gypsum was converted to plaster of Paris by roasting on only a small scale, as the product did not then have wide usage, but the adoption of this kind of plaster for walls in buildings, especially as a finishing coating, because of its superior hardness and whiteness, has made its production a large and profitable industry. When mixed with cement it acts as a retarder, greatly increasing the value of that product, and for gypsum to be used in this way there is now a large demand. As land plaster or fertilizer the gypsum is simply ground and not roasted. It has proved very beneficial to certain soils and for certain crops, being highly recommended for peanut cultivation.

Present development.—Two gypsum companies are operating in the area at the present time. The United States Gypsum Co., with offices in Chicago, leased the Robertson tract, adjoining the Mathieson Alkali Co.'s property on the southwest, from the Buena Vista Plaster Co. and has been operating for the last few years. This plant is located in a narrow extension of the broad flat at Saltville, separated from it by a low divide. Two shafts furnish access to the workings, which are reported to be about 100 feet below the surface, each set of workings seeming to be in a distinct body of gypsum. A third abandoned shaft leads to another mass of the deposit, and as other new bodies are located by drilling over the bottom land additional shafts will be sunk. Large deposits of gypsum on the eastern edge of the tract directly adjoining the Mathieson property were previously worked out by the owners.

As just mentioned, the gypsum in this mine seems to be in detached masses of great size and not in continuous beds, as might be expected.

This will be referred to again later under the heading "Origin of the Deposits." The gypsum is mostly a white to gray granocrystalline rock inclosed in clay, the gray variety streaked with fine dark argillaceous material. Numerous small anhydrite crystals are scattered through some of the gypsum from the old southernmost shaft, and these appear more prominently on weathered specimens. The gypsum is brought to the surface by elevators and conveyed by tram cars to the company's mill, where it is roasted and pulverized. The molding of plaster bricks, tiles, and hollow blocks in the company's shop is a new branch of the industry in this region.

The Southern Gypsum Co.'s plant and office are at North Holston, reached by the company's branch railroad from Saltville. The mine is on the old Pierson plaster-bank farm, in one of the embayments of lowland adjoining the North Fork of Holston River which is underlain by the soft shales of the Maccrady formation. The shaft in the lowland is connected by an aerial bucket tram with the main roasting and grinding plant at the railroad on the hillside. A large part of the crude product is ground for fertilizer at the lower mill near the shaft, much of the gypsiferous clay being of the right mixture to be used in this way for land plaster, effecting a great saving in the expense of mining. For wall and finishing plaster and cement retarder only the purer lump gypsum is employed.

The bulk of the gypsum here is much like that at the United States Co.'s plant, granular and crystalline. Some large sheets of pure selenite are encountered, and small veinlets of satin spar are common in the clay. Large masses of black argillaceous material called "black rock" occur in the midst of the gypsum, and apparent bedding of the gypsum is indicated by banding of black grains of the same material. The gypsum is reported to occur in beds of considerable thickness and extent and not in isolated masses, as at the United States Co.'s mine. The deposits have been tested by bore holes over all the river bottom of the embayment. The beds vary greatly in thickness, however, being somewhat lenticular in shape. The gypsum formerly outcropped at the river, where it was mined in open cuts in the early days for fertilizer. It is now mined from the shaft in the bottom land in all directions at a maximum depth of about 100 feet.

Deposits not at present utilized.—Old partly filled pits where gypsum, or "plaster," as it is commonly called, was mined from the surface in earlier days are visible all along this belt from a point a mile west of Plasterco to the vicinity of Chatham Hill. Large quantities of good gypsum still remain in these old workings. Near Plasterco large pits,

abandoned shafts, and caved-in ground abound, marking the places where the Buena Vista Co. and the Robertsons formerly operated extensively and removed much of the available gypsum that was close to the surface. Smaller openings were made in the embayment about 1 mile to the southwest, but the deposits there have been only slightly explored. They are all owned by the old Buena Vista Co. and are leased to the United States Gypsum Co. In the Saltville Valley thick deposits of gypsum are reported in all the wells drilled for salt, and some beds at the surface were formerly mined for the manufacture of a kind of cement. They are owned by the Mathieson Alkali Co. and are not now being worked.

At North Holston and in the embayment just east of it several old gypsum pits formerly worked on the Pierson and Miller farms are nearly obliterated. Several old pits are to be seen also near Broad Ford, some to the west but most of them in the broad embayment to the east. One is still open in the river bank on the Taylor farm, about a mile east of Broad Ford, where the gypsiferous shales have been dug out from beneath the overthrust Cambrian dolomite. Another pit on the Taylor farm is among the low hills to the northeast, beyond the point where the North Fork of Holston River leaves the belt of the Maccrady formation. A shaft on the adjacent Barnes place opened a large deposit by drifts but is now abandoned and filled with water.

Northeast of the Taylor farm conditions continue to appear favorable for the occurrence of gypsum, except that the exposed area of the Maccrady formation is narrow, but gypsum is not known to have been reported in the next 3 miles. Beyond, however, on the Buchanan property, important deposits occur and were mined on a large scale and crushed in the company's mill on the property. The smaller holes have fallen in and been filled up, but some of the larger ones are full of water and are reported to be very deep. Pits are scattered over the broad embayment in the Maccrady formation not only in the Locust Cove Creek bottom but also on the low divide and small valley to the west. Several pits were also located north of Chatham Hill, and the crude gypsum was crushed in a water-power mill on the river at Chatham Hill.

ORIGIN OF THE DEPOSITS.

Former Views.

In his early description of these deposits W. B. Rogers correctly identifies the beds inclosing them as "Lower Carboniferous" and states further that they are at the fault contact between these beds and older

limestones. As to their origin he adopts the explanation that oxidizing iron pyrites in the shales produced sulphuric acid, which, acting on limestone, converted it into calcium sulphate. He says:[a]

In speculating upon the origin of the gypsum of this region, the readiest explanation that suggests itself is that which ascribes its production to similar causes with those which gave birth to the gypsum of the Tertiary strata of lower Virginia. It has been incidentally remarked above that pyritous slate occurs in fragments mingled with the gypsum and clay of the salt wells and other places. Supposing the valley to have once been filled with the débris of this slate and of the neighboring limestones, we would have all the materials brought together which are necessary for the production of the gypsum, while the slate after decomposition would become the clayey matrix in which the crystals would collect. This view is rendered more probable from the occurrence, even in the midst of the solid masses of plaster, of fragments of the siliceous rock which skirts the valley on the south. It is at least certain that the gypsum has not been deposited here, as in some other parts of the world, from the waters of thermal springs holding it in solution, since in that case it would be found disposed in layers as travertine and not in the irregular and scattered condition which has been described.

J. J. Stevenson,[b] in 1885, after describing the mining development, occurrence, and distribution of the gypsum and salt, arrives at somewhat similar conclusions, as follows:

1. The gypsum deposits are not beds of Carboniferous or Cambro-Silurian limestones changed into gypsum.
2. These deposits occupy deep basins, which have been eroded in Lower Carboniferous shale or limestone or in the hard, slightly calcareous sandstones of the Knox group. In at least two localities branches protrude from the main body into drains or ravines, so that the horizontal plan resembles somewhat the splash made by throwing soft mud against a wall.
3. The character of the deposit is wholly independent of the rocks on which it rests.
4. The gypsum occurs in irregular masses, incased in red marly clay, which penetrates the gypsum to a variable distance; there is less of this clay in the eastern basins than at Saltville.
5. At a variable depth salt occurs with the gypsum, and this salt contains very little of iodides or bromides.
6. Blue clay overlies the gypsum at all localities yet examined.
7. No fossils of any sort have been found thus far in the gypsum, its incasing red clay, or in the overlying blue clay; but just west from Saltville a conglomerate cemented by gypsum occurs, in which remains of Mastodon have been found; this overlies the blue clay and incloses many fragments of both blue and red clay.
8. These gypsiferous deposits occur in the vicinity of the Saltville fault.

. . . .

But the amount of the erosion and the general relation of the gypsum to the blue clay, with the relation of the latter to the Quaternary conglomerate, suggest that the gypsum is not older than the Tertiary; until some fossils have been discovered, however, the question of age must be regarded as undetermined.

. . . .

Capellini ascribes the formation of this gypsum [at Castellina Marittima] to the action of sulphur springs on calcium carbonate held in solution; so that the

[a]Rogers, W. B., A reprint of annual reports . . . on the geology of the Virginias, 1884, pp. 141-142.
[b]Proc. Am. Philos. Soc., vol. xxii, 1885, pp. 157-160.

carbonate was changed into sulphate and deposited as such in the littoral lakes of the middle Miocene. . . . The origin of the Holston gypsum is to be accounted for in some similar way. Several deep basins were occupied by lakes; that of the Saltville basin received not a little calcareous matter from the Lower Carboniferous beds forming its northerly shore, and some doubtless was received from the wash of the Knox beds on the southerly shore; in the basins farther east the calcareous matter derived from the wash should be far inferior to argillaceous matter. But the composition of the gypsum shows less of the red clay at Buchanan's than at Saltville. The principal source of the calcareous matter must be looked for not in the wash from the shores but in springs. That calcareous springs can produce deposits as extensive as those of this region is sufficiently shown by the extensive deposits around many of the springs at the far West. The calcium carbonate in solution would be converted into calcium sulphate by the sulphurous springs also issuing from the fault, and the gypsum would be deposited as such.

The red marly clays were derived from the wash and are more abundant at Saltville, where the soft red shales at the top of the Lower Carboniferous are fully exposed on the northerly side of the basin.

E. C. Eckel,[a] in 1902, concluded that the deposits were interbedded as original sediments in the "Lower Carboniferous":

Though the salt and gypsum deposits have been long known and worked and have been examined by many geologists, a wide range of opinion exists as to their age and origin, as will be seen on comparing the literature of the subject. It is sufficient in this place to note that, as to age, the deposits have been variously referred to the Silurian, Carboniferous, Triassic, Tertiary, and Pleistocene, while different authorities have considered them as originating from deposition from sea water, from deposition from lakes, by the decomposition of pyrite and resulting action on fragments of limestone, or by the action of sulphur springs on unweathered limestone.

The work of the last field season would seem to prove that both the salt and gypsum deposits originated from deposition, through the evaporation of sea water in a partly or entirely inclosed basin, and that they are of Lower Carboniferous age, being immediately overlain by the massive beds of the Greenbrier limestone and underlain by Lower Carboniferous sandstones.

Observed Relations.

The most striking fact in connection with the gypsum and salt deposits of this district is that they have been found in quantity only in the shales of the Maccrady formation along the Saltville fault. These shales also outcrop along the North Fork of the Holston southwest of Saltville, on the west side of the syncline, but so far as known neither gypsum nor salt has been observed in this area of the formation. Stevenson reported gypsum on both sides of the fault on the Miller and Buchanan tracts northeast of Saltville, but these observations seem to be in error in that the fault was not accurately mapped, which is not strange, for the altered Carboniferous limestone very closely resembles the Cambrian dolomite, and some of the red shales of the Cambrian closely resemble those of the Carboniferous.

[a]Bull. U. S. Geol. Survey No. 213, 1903, p. 406.

An effort has been made to obtain a carefully measured section of the Maccrady formation to determine the position of the gypsum and salt-bearing beds, but with scant success. In the broad flats where the gypsum occurs there are generally no outcrops except red clay and gypsum, and consequently there is little hope of solving the relation southwest of Saltville. Not even the base of the Maccrady, which is the most definite key horizon, is exposed there.

Northeast of Saltville there are a few good exposures, but generally where the gypsum occurs the inclosing rocks are soft clays and are hidden. The river cliff southwest of Maccrady is the best exposed section of these beds in the area, and the following details were measured there:

Partial section of Maccrady formation west of Maccrady, Va.

	Thickness
	Feet.
Dark crumbly fossiliferous shale and earthy gray limestones	50±
Alternate thick earthy limestone, calcareous shale, and thin crystalline fossiliferous limestones	60
Massive-bedded bluish tough calcareous and argillaceous sandstone with fossiliferous calcareous layers	25
Gray sandstone, weathering brown	5
Shaly earthy contorted sandy limestone	31
Hard thick-bedded bluish calcareous sandstone	20
Softer shaly earthy sandstone	30
Thick bed of earthy sandstone	6
Hard impure limestone, with chert nodules	8
Thick soft earthy sandstone	10
Shaly earthy limestone	60
Thick-bedded to shaly earthy sandstone	45
Covered, probably some red shale, shaly earthy limestone, and soft earthy sandstone	225±
Red shaly sandstone and shale, mottled yellow	10
Red shale in part, rest covered	25
Red shaly sandstone, mottled yellow	7
Shaly gray sandstone, with phosphatic fish plates	10
Sandy shale, in part covered	20
Soft shale, light buff to dark drab; light-gray fire clay with rootlets, leaves, and twigs at base	20
Black coaly fissile shale	1
Slabby blue even-grained irregular-bedded sandstone, weathering buff (top of Price sandstone).	

The next best partial section is just east of Watson Gap, 2 miles southwest of Broad Ford, which is as follows:

Partial section of Maccrady formation east of Watson Gap, Va.

	Thickness
	Feet.
Thin-bedded earthy limestone, with some hard dense beds	30
Purple fissile shale, with some earthy limestones	14
Fissile red shale	10
Micaceous red sandstone, mottled yellow	4
Fissile and crumbly red shale, mottled yellow	37
Hard yellow and red agglomeratic shale	1
Crumbly red sandstone and some yellow shale	10
Harder red sandstone, in part shaly	4
Red argillite and shale, with drab sandy concretionary masses	3
Greenish fire clay, with rootlets, red at surface	2
Crumbly and fissile red and yellow shale	30
Soft greenish micaceous sandstone, purplish at top	20
Soft yellow shale	4
Black fissile coaly shale	3
Thin sandstone and fire clay, with rootlets	1
Greenish fissile shale	10
Thin irregular-bedded sandstone	8
Sandy light-buff fire clay, with rootlets	3
Covered, probably thin sandstone and shale	10
Massive-bedded greenish-gray calcareous sandstone (top of Price sandstone).	

Just east of Broad Ford is another fair exposure that shows the relations of the gypsiferous shales to the rest of the formation:

Partial section of Maccrady formation east of Broad Ford, Va.

		Thickness
		Feet.
Soft red and green shale and clay, with some soft thick brown sandstone and earthy limestone Red and green shale Red rippled sandstone Gray shale with red sandstone bed Red shale and sandstone Gray shale	Weather or change laterally into gypsum-bearing red plastic clays with secondary limestone layers	150
Thin black fissile coaly shale		1
Earthy limestone and calcareous shale		12
Covered, probably in part soft earthy limestone		40+
Red sandstone and sandy shale (with unexposed gray sandstone, shale, and carbonaceous seams to base of formation), estimated		130±

From the relations observed in the northeastern part of the area it may be stated that the gypsum does not occur in the lower red siliceous beds of the formation and probably not lower than 180 feet from the base; that thin-bedded argillaceous limestones which are characterized by a small spirifer resembling *S. bifurcata* generally occur near the top of this barren interval; that the gypsum seems to replace certain soft earthy sandstones, shales, and limestones in the overlying portion of the formation present in that part of the area.

Southwest of Saltville, where the surface exposures do not show the relations of the gypsum, the well records also do not aid much in their solution. From a glance at the records of the Mathieson Alkali Co.'s borings, kindly permitted by Mr. W. D. Mount, manager of the plant, no clue was gained as to the sequence of the gypsum and salt beds or of their relation to recognizable limestone, sandstone, or hard red sandy beds. The basal barren sandy beds were not observed, even in the deepest well. A generalized record of one of the typical wells of the Mathieson Co. illustrates the relative distribution of the gypsum and salt which prevails throughout most of the sections.

Generalized section of a well at Saltville, Va.

	Thickness	Depth
	Feet	*Feet*
Limestone and shale	26	26
Shale and gypsum	195	221
Mostly shale with gypsum and some rock salt	359	580
Mostly limestone with shale, gypsum, and rock salt	215	795
Mostly shale with gypsum and rock salt	100	895
Mostly rock salt with little shale	197	1,092

The record of a well on the Buena Vista Plaster Co.'s property at Plasterco, as given by T. L. Watson, is as follows:

Section of well at Plasterco, Va.

	Thickness	Depth
	Feet	*Feet*
Red clay	10	10
Clay and plaster	6	16
Impure plaster	34	50
Pure plaster	52	102
Slate and plaster	63	165
Nearly all plaster	45	210
Blue slate	110	320
Blue slate and plaster	70	390
Yellow soapstone	55	445
Pure plaster	45	490
Red rock with little salt	15	505

The distribution of gypsum throughout several hundred feet of strata in the wells at Saltville and Plasterco indicates that, even if the beds have a relatively steep dip, the gypsum has a wide vertical range in the southwestern part of the area and may replace higher beds in the formation than occur at the surface in the northeast.

Conclusions.

It can not be determined positively from the well records whether the deposits are in thick continuous beds or, as has been found to be the condition in the mines at Plasterco, in detached segregated masses. The distinct interbedding, however, of the gypsum with limestone, shale, red clay, and rock salt in the Saltville wells precludes the idea that the deposits were formed in wash from the surrounding higher areas into a trough or lake, as suggested by Stevenson. The gypsum beds have nowhere been mined deep or far enough to determine how they change laterally into other sedimentary rocks. This must be inferred from such facts as can be gathered in the mines, on the surface, and in the well records.

The conclusion expressed by Eckel that the deposits are strictly sedimentary in origin, having been derived from the evaporation of confined bodies of water under salt-pan conditions, is believed by the writer to be only partly correct. The fact that the beds of almost solid gypsum 50 to 100 feet in thickness vary greatly, occurring at intervals along the belt of these rocks, with barren areas between, and, so far as known, not at all on the northwest side of the syncline away from the fault, does not harmonize with this view. That salt-pan conditions could be so local and still persist for so long a time as to form such thick beds of gypsum and that these conditions could be repeated over and over again in the same place while not occurring at all in intervening areas is highly improbable.

The facts that the gypsum is segregated in workable deposits in the Maccrady formation at intervals along a fault contact, with barren areas between, and that none occurs in the same formation, so far as known, where not adjacent to the fault, are more reasonably explained by assuming, first, that gypsum was originally deposited as disseminated grains and innumerable thin leaves with argillaceous and calcareous silt and earthy sand of the Maccrady formation in a partly inclosed arm of the sea, at times subjected to intense evaporation; second, that the gypsum was later concentrated in the same formation by ground waters, which, circulating along the fault, dissolved part of the disseminated calcium sulphate and redeposited it in adjacent gypsiferous beds, the gypsum being segregated

by chemical selection. The calcium carbonate in the calcareous silt was likewise dissolved by the meteoric waters and the gypsum has taken its place, possibly by direct replacement, the waters, being carbonated, dissolving the calcium carbonate and depositing the calcium sulphate.

A sample of unaltered earthy limestone from the horizon of the gypsum-bearing clays of the Maccrady formation near Broad Ford was analyzed for F. A. Wilder, president of the Southern Gypsum Co., and was reported to contain 4 per cent of $CaSO_4$. Another sample from the limestone quarry across the river from the Mathieson Alkali works, analyzed in the chemical laboratory of the U. S. Geological Survey, showed 3.16 per cent of $CaSO_4$ present. This may represent the amount of disseminated gypsum present in the original calcareous silt.

In addition to the facts mentioned above pointing to this conclusion, several other observations may be cited. The occurrence of large crystalline sheets of selenite in the granocrystalline mass and especially of small veinlets of satin spar in the otherwise barren inclosing clay, affords positive proof that solution and redeposition may have taken place to some extent. The massive gypsum has the appearance of bedding, due to the banding of gray impurities, but on close observation this is found to be not sedimentary banding parallel to the inclosing strata but concentric banding parallel to inclosed bodies of "black rock," fine particles of the argillaceous material producing the dark banding. These argillaceous masses may have resulted from less soluble clayey masses in an otherwise calcareous gypsiferous bed which was gradually encroached upon during the concentration of the gypsum and particles of it were left as banded impurities in the gypsum; similar drab argillaceous concretionary masses were observed in the red argillite 94 feet above the base of the Maccrady formation on the road east of Watson Gap. Or, on the other hand, the argillaceous impurities may have been segregated in the rounded masses by chemical repulsion during the concentration and purification of the gypsum. At least, both the banding of the gypsum and the rounded masses of argillaceous "black rock" appear to have resulted from the secondary segregation of the gypsum. The red plastic clay that generally incloses the gypsum is probably the fine argillaceous impurity of the earthy limestone left as a residuum, expelled by the crystalline segregation of the gypsum, and stained red by contained iron highly oxidized when set free during the process. Thin layers of fine-grained limestone in the gypsiferous clays were apparently redeposited from solution as another secondary mineral.

This theory as to the method of the concentration of gypsum is not new, for it has been proved beyond much doubt that the remarkable domes

of salt and gypsum in Louisiana and Texas were formed by the deposition of these minerals along spring lines at the exposed intersection of fissures or faults,[a] having been dissolved and transported from some deeper-lying beds. Secondary limestone, apparently similar to the crackled layers in the clays of the Holston Valley area, also occur in the domes associated with the salt and gypsum. The fact that the Louisiana deposits were derived from lower beds suggests the possibility that the salt and gypsum in the Holston Valley area were also derived from beds at a lower horizon, that the solutions rose along the fault, and that these minerals were deposited at or near the surface in their present position. This explanation, however, is untenable, inasmuch as none of the older formations which outcrop to the west on the slopes of Clinch Mountain—not even the representative of the Salina, the great salt and gypsum bearing formation of New York—contain deposits from which these minerals could have been derived, and furthermore, as such strictly secondary deposits would be found only at or near the surface, whereas the Holston Valley deposits occur interbedded in the Maccrady formation to considerable depths.

If the theory of secondary concentration above suggested is the correct explanation of the origin of the gypsum in the Holston Valley area, it accounts for the absence of the mineral in quantity on the west side of the syncline away from the fault, the occurrence of natural outcrops of gypsum close to the fault, and the greater thickness of the deposits toward the southeast, as developed by borings in the Saltville, Plasterco, North Holston, and other tracts tested. In accordance with this theory it may be predicted that the gypsum will be found to extend under the overthrust Cambrian dolomite as far as the Maccrady formation is at the fault contact, and when the deposits near the surface are worked out deeper mining may be carried in this direction.

The beds of rock salt undoubtedly had the same origin as the gypsum and may be regarded as concentrations of somewhat saliferous beds, the associated calcium carbonate of the earthy limestone being dissolved out and its place taken by salt, segregated by solution and redisposition through chemical selection. Whether workable beds will be found associated with all the gypsum deposits can not at present be determined, but where salt has not been encountered in mining the gypsum there is still a prospect that it may be discovered at greater depth close to or under the overthrust dolomite. This is especially true southwest of Saltville,

[a] Harris, G. D., Rock salt: Bull. Louisiana Geol. Survey No. 7, 1907; Oil and gas in Louisiana: Bull. U. S. Geol. Survey No. 429, 1910.

where the overriding Cambrian limestone conceals most of the Maccrady formation, as it is apparently turned under in a minor anticline next to the fault. Southwest of Plasterco both salt and gypsum may be expected along the fault some distance from its outcrop under the overthrust mass where the Maccrady formation is probably at the fault contact. This may be proved by either drilling through an unknown thickness of tough dolomite southeast of the fault or boring diagonally under it in the soft rocks at the fault contact.

SUMMARY.

The gypsum and salt deposits of southwestern Virginia described in this report are believed by the writer to have been derived from calcareous-argillaceous sediments which originally contained disseminated gypsum and salt precipitated in a partly inclosed arm of the sea during the deposition of the Maccrady formation, these minerals having been concentrated in the same formation by ground waters which circulated along the fault contact between the Carboniferous and Cambrian rocks, dissolved the calcium carbonate from the earthy limestones, and segregated the gypsum and salt in the gypsiferous and saline beds by chemical selection.

INDEX

VIRGINIA GEOLOGICAL SURVEY
UNIVERSITY OF VIRGINIA
THOMAS LEONARD WATSON, PH. D.
DIRECTOR

Bulletin No. IX

The Coal Resources and General Geology of the Pound Quadrangle in Virginia

BY
CHARLES BUTTS

PREPARED IN COÖPERATION WITH THE
UNITED STATES GEOLOGICAL SURVEY

CHARLOTTESVILLE
UNIVERSITY OF VIRGINIA
1914

J. P. BELL COMPANY
INCORPORATED
Printers
Designers
& Engravers
Lynchburg, Va.

STATE GEOLOGICAL COMMISSION

CONTENTS

ILLUSTRATIONS

LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, March 16, 1914.

To His Excellency, Hon. Henry C. Stuart, Governor of Virginia, and Chairman of the State Geological Commission.

SIR:—I have the honor to transmit herewith for publication, as Bulletin No. IX of the Virginia Geological Survey Series of Reports, a report on "The Coal Resources and General Geology of the Pound Quadrangle in Virginia," by Mr. Charles Butts of the U. S. Geological Survey.

This report has been prepared by the Virginia Geological Survey in coöperation with the U. S. Geological Survey. Under the coöperative agreement of the State and Federal Surveys the entire region of Pennsylvanian coals in southwest Virginia, approximating 1,550 square miles of territory embracing the whole or parts of Tazewell, Buchanan, Dickenson, Wise, Russell, Scott, and Lee counties, is being studied and mapped both topographically and geologically, in detail.

The present report is the first to be published under this coöperative plan; and, in view of the author's conclusions as to the quantity and quality of coal, the report should prove of much value in the development of the coals of the quadrangle. The coal is bituminous and of excellent quality. Mining conditions seem highly favorable and the region should, with development, become one of the principal coal-producing centers of the central Appalachian coal field.

Respectfully submitted,
THOMAS L. WATSON,
Director.

THE COAL RESOURCES AND GENERAL GEOLOGY OF THE POUND QUADRANGLE IN VIRGINIA

BY CHARLES BUTTS.

INTRODUCTION.

The Pound quadrangle includes parts of Pike and Letcher counties, Kentucky, and Wise and Dickenson counties, Virginia. It is located a few miles northwest of the Toms Creek coal field, in the territory between the great Pocahontas coal field on the northeast and the Big Stone Gap field on the southwest. Until recently the region was entirely undeveloped and little information concerning it was available. It has not, however, escaped the attention of coal operators, and some of the largest corporations have been acquiring lands in this region with a view to active development. Within the last three years railroad communication with the outside world has been established, and on the Kentucky side fourteen shipping mines are in active operation. On the Virginia side only one large mine has been operated, but doubtless others will be established in the near future.

The number of coal beds in the quadrangle is probably greater than elsewhere in the Appalachian coal field, and in the thickness and extent of its beds the area will compare favorably with most others in that field. These factors, combined with the excellent quality of the coal, insure the area a prominent place among the future fuel-producing centers of the Appalachian province.

The geologic examination of the Virginia portion of the Pound quadrangle was carried on in 1911 jointly by the Virginia Geological Survey and the United States Geological Survey. The United States Geological Survey had charge of all field work, but it was ably assisted by men and money supplied by the Virginia Geological Survey. An accurate contoured topographic map of the quadrangle was made and this will be ready for distribution as soon as it is engraved.

In the survey of the Virginia part of the quadrangle the writer was ably assisted by D. D. Condit and Wilbur A. Nelson, both of whom represented the Virginia Geological Survey. The Clinchfield Coal Corporation, which has extensive holdings in Wise, Dickenson, Buchanan, and Russell counties, Virginia, has contributed invaluable data dealing with triangulation surveys, coal-outcrop surveys, diamond-drill borings, etc.

Extensive prospecting by the same company has opened several of the more important coal beds to more thorough examination. The Virginia Coal and Iron Company, operating in Wise County, Virginia, has also made many openings and has contributed maps of outcrop surveys which have been of great assistance. The Estillville and Bristol folios of the United States Geological Survey, by M. R. Campbell, and United States Geological Survey Bulletin 348, by R. W. Stone, have also been drawn upon for any material that could be used in the preparation of this report.

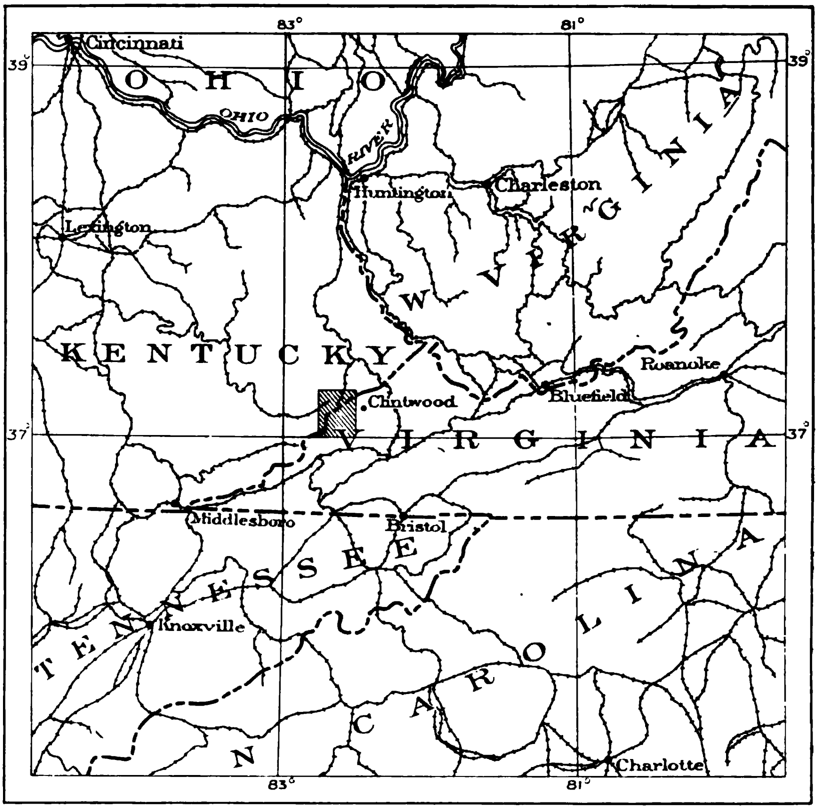

FIG. 1. Index map showing the location of the Pound quadrangle.

As shown by the key map, figure 1, the Pound quadrangle, which coincides with the southeastern quarter of the old Whitesburg 30-minute quadrangle, lies partly in eastern Kentucky and partly in southwestern Virginia. The line between the two states follows the crest of Pine

Mountain nearly to the west boundary of the quadrangle, where it turns south along the watershed between Cumberland and Pound rivers. The quadrangle is bounded on the north and south by the parallels of 37° 15′ and 37°, respectively, and on the east and west by the meridians of 82° 30′ and 82° 45′. Its area is about 240 square miles, lying entirely in the Appalachian coal region.

TOPOGRAPHY.

Relief.

The surface of the country is hilly or even mountainous, the maximum range of altitude from Pound River to Black Mountain being 2,300 feet. Pine Mountain, with peaks that reach 3,500 feet above sea-level, crosses the northern half of the area from northeast to southwest, and Black Mountain, whose summit is 3,800 feet above the sea, 1,800 feet above Roaring Fork, and 1,550 feet above Guests River, is located in the southwestern part of the quadrangle. These mountains are the dominant features of the region. Buck Knob and Bowlecamp Knob, at an altitude of about 1,500 feet above Indian Creek, are also commanding objects in the landscape.

The northwest slope of Pine Mountain is an escarpment 1,500 to 2,000 feet high, and, as the crest is scarcely a mile from the valleys at the foot of the slope, a very bold and striking front is presented. The southeast slope of the mountain, approximately a dip slope on the Lee sandstone, is more gentle, the total descent being somewhat less and the distance to the foot nearly twice as great as on the northwest side.

The quadrangle is deeply dissected by the streams, the valleys of which are deep, narrow, and V-shaped. The slopes are very steep and rise 500 to 1,000 feet to the ridge crests, which are commonly only a few feet broad and many of which are capped with heavy cliff-forming sandstone. Even the larger streams have very narrow flood plains, and many of them have none at all. Probably 5 per cent would be a liberal estimate for the total area of flat land in the quadrangle. The ridges and valleys trend in irregular directions over most of the Virginia portion of the quadrangle.

Drainage.

The principal streams in the Virginia area are Pound River, including North and South forks, which traverses the quadrangle from southwest to northeast near the middle; Roaring Fork, Powell River, and Guests River,

in the southwestern part; Indian Creek, which flows due north through the middle of the southern part of the quadrangle and joins Pound River at Pound; and Birchfield Creek, in the southeastern part, which joins Cranes Nest River, a tributary of Pound River, just outside of the eastern margin of the quadrangle.

Pound River is the largest stream. It is doubtful whether any of the smaller streams or even Pound River carries much water in times of prolonged drought.

The Virginia part of the Pound quadrangle includes parts of two drainage basins. The area drained by Pound River and its tributaries, including Indian and Birchfield creeks, belongs to the Ohio-Big Sandy basin; that drained by Guests and Powell rivers to the Tennessee-Clinch basin.

ACCESSIBILITY.

In a potential mining country like this area the matter of transportation and consequently the conditions affecting railroad construction are of the first importance. The nearest main lines of railroad are the Norfolk and Western Railway and the Louisville and Nashville Railroad at Norton, about 4 miles south of the quadrangle; the Louisville and Nashville Railroad at Pineville, Kentucky; the Chesapeake and Ohio Railway along the Big Sandy River in Kentucky; and the Carolina, Clinchfield and Ohio Railroad, now being extended from Dante, Virginia, to Elkhorn City, Kentucky, near the "Breaks of Sandy."

The country herein described is still poorly provided with transportation facilities. The territory drained by Guests River could easily be reached by a railroad from Norton, but the Pound River drainage area presents serious obstacles to railroad construction. To build a railroad from the south would involve steep grades or an expensive tunnel at the head of Indian Creek. The railroad now existing along Indian Creek is a narrow-gage road built to haul logs from Pound River to a sawmill at Glamorgan, where it connects with the standard-gage road to Norton. A branch line from the Carolina, Clinchfield and Ohio Railroad up Pound River would, on account of the narrow and crooked valley, be expensive to construct and operate. The area drained by the upper part of Pound River and its tributary Indian Creek could perhaps be most advantageously reached by a line from the Louisville and Nashville Railroad at Pineville, Kentucky, following Cumberland River and crossing the low divide at Flat Gap. A railroad just beyond the southwest corner of the quadrangle connects with

the Interstate Railroad at Blackwood a few miles to the south and follows Roaring and Whitley forks to the Pardee mine. It seems perfectly feasible to build a spur up the main branch of Roaring Fork to the base of Black Mountain. The territory tributary to Birchfield Creek and Georges Fork can apparently be best reached from the Carolina, Clinchfield and Ohio Railroad along Pound and Cranes Nest rivers. The northwestern part of the area along Pound River is nearest to the Baltimore and Ohio Railroad at Jenkins, but, owing to the intervening Pine Mountain, this railroad can be of little service to the Virginia region except in the matter of travel and light traffic.

STRATIGRAPHY.

General Statement.

The rocks outcropping in the Pound quadrangle belong to the Devonian and Carboniferous systems. The Devonian rocks, the lowest and oldest exposed in the quadrangle, outcrop only on the west escarpment of Pine Mountain in Kentucky and consist of about 800 feet of dark to black shale, the lower part of which is classed as Chattanooga black shale and the upper part of which is included in the Grainger shale in reports on adjoining quadrangles. The Carboniferous system is represented by the Mississippian series below and the Pennsylvanian series ("Coal Measures") above. Each of these series is made up of a number of formations, which are described below.

Mississippian Series.

The Mississippian series in this area is 1,500 to 1,600 feet thick and comprises three subdivisions, which, in ascending order, are the upper part of the Grainger shale, the Newman limestone, and the Pennington shale. The upper part of the Grainger shale is composed chiefly of green shale and brownish sandstone, but in the upper 50 feet there is considerable red sandstone. The Mississippian part of the formation occurring in this area appears to be 400 to 500 feet thick. The Grainger is overlain by the Newman limestone, about 300 feet thick, which is oolitic and thick bedded in the lower half, but thinner bedded and with only a few oolitic layers in the upper half. The Newman is overlain by the Pennington shale, which is about 800 feet thick and is composed of red and green shale, thin-bedded, fine-grained green sandstone, and one persistent stratum of hard, siliceous sandstone 100 feet thick.

The Mississippian rocks outcrop only on the northwest front of Pine Mountain in Kentucky, and dip southeastward under the coal measures in Virginia. The Mississippian part of the Grainger shale is partly exposed on the Pound Gap road and on the Blowing Rock road 2 or 3 miles beyond the east margin of the quadrangle. The red sandstone layers are especially well shown on the Blowing Rock road at the part known as the "Red Winds." The Newman limestone is exposed on the Pound Gap road and outcrops as a cliff along much of the mountain front. The Pennington shale is fairly well exposed on the Pound Gap road immediately west of the summit. Near the road its siliceous sandstone member outcrops as a cliff and half a mile or so north of the road it makes another cliff known as the Raven Rock. The Pennington shale was penetrated at a depth of about 2,000 feet in diamond-drill boring No. 1 on Cranes Nest River near the mouth of Lick Fork, a short distance east of the quadrangle. (See Pl. I.)

PENNSYLVANIAN SERIES.

The Pennsylvanian series in this area is 4,800 feet thick and consists of shale and sandstone containing 46 or more coal beds. These rocks, all of Pottsville age, were divided by Campbell[1] into the following formations, named in ascending order: Lee conglomerate, Norton formation, Gladeville sandstone, Wise formation, and Harlan sandstone. The character of the rocks, the sequence of formations, and the number, position, and succession of coal beds are shown in the columnar section accompanying this report (Pl. III). This section is partly generalized, but the section of the Lee is taken from the log of a bore hole on Cranes Nest River just outside the east margin of the quadrangle, and the part of the section of the Wise formation above the Bolling (5-foot) coal beds and the section of the Harlan sandstone were measured at the head of South Fork of Pound River, the section extending from the base of Black Mountain to the summit. The Black Mountain section of the Pennsylvanian is probably the thickest in the Appalachian province outside of the Coosa and Cahaba troughs in Alabama.

LEE FORMATION.

The Lee formation, as delimited by the writer in the log of the well boring on Cranes Nest River (sec. 1, Pl. I) is 1,030 feet thick. It is predominantly sandstone, which at the top and bottom of the formation is

[1] Campbell, M. R., Geology of the Big Stone Gap coal field of Virginia and Kentucky: U. S. Geol. Survey Bull. 111, pp. 33–36, 1893.

conglomeratic. At the base is about 230 feet of massive conglomeratic sandstone. This sandstone forms the crest of Pine Mountain, where it outcrops for long distances as a cliff. Above the basal sandstone is 250 feet of alternating shale and sandstone, in which are six coal beds at about equal stratigraphic intervals and from 6 inches to 2 feet 2 inches thick. Three of the beds are workable, being 1 foot 2 inches, 1 foot 6 inches, and 2 feet 2 inches thick. Above this group of coal beds the well log shows 550 feet of sandstone with a 2-inch coal bed 225 feet above its base and a 1-foot 7-inch bed 400 feet above its base, the two beds being 700 and 875 feet, respectively, above the bottom of the formation. The upper 160 feet of the Lee is a hard, siliceous conglomeratic sandstone, the pebbles being small and scattered. This stratum, dipping southeastward, forms the lower part of the southeast slope of Pine Mountain, and its outcrop on the slope is marked by a subordinate ridge or line of knobs parallel with the general direction of the crest of the mountain.

The Lee formation outcrops in a zone about 2 miles wide which extends diagonally across the quadrangle from the northeast corner. Its base forms the crest of Pine Mountain, and, owing to the southeastward dip, successively higher beds of the formation are encountered in descending the southeast slope. In reality the presence of a mountain ridge here is determined by the inclined beds of this hard, resistant sandstone and conglomerate. Besides this main area of outcrop, the Lee is exposed in a long, narrow area low down on the northwest escarpment of Pine Mountain, in contact with the Devonian rocks or with the Mississippian part of the Grainger shale on the east, and with coal-bearing rocks, in part probably equivalent to the Wise formation, on the west. This narrow area is an outcrop of a segment of the Lee, which was broken off and thrust upward along a fault, as described in the section on geologic structure. The massive sandstone strata of the formation are well exposed in the "Breaks of Sandy," 12 miles northeast of the Pound quadrangle, where the Lee forms canyon walls nearly 1,000 feet high.

NORTON FORMATION.

A fairly reliable determination of the thickness of the Norton formation is made by combining the upper part of the bore-hole section on Cranes Nest River (sec. 1, Pl. I) with the surface section of a high knob immediately adjacent to the hole. The contact between the Lee and the Norton, as the log is interpreted, is 879 feet above the sea and the horizon of the bottom of the Gladeville sandstone, which is the top of the Norton for-

mation, is approximately 2,070 feet above the sea. The thickness of the Norton is therefore 1,191 feet.

The character of the Norton formation is well shown in the group of bore-hole sections in Plate I, from which the generalized columnar section of the formation in this quadrangle is taken. Its most striking feature is the variability in the number and position of the coal beds, a feature which makes it difficult to give a satisfactory, brief, general description of the formation. In general the formation is made up of shale and sandstone, with coal beds, the more important of which are approximately 190, 320, 410, 560, 730, and 930 feet above the bottom. Eighty feet below the Gladeville is a conglomeratic sandstone 50 feet thick, which may prove to be the same as the Bearwallow conglomerate of the Tazewell quadrangle, 30 miles east of this area.

In the Pound quadrangle the Norton formation outcrops in a belt about 1½ miles wide extending diagonally across the quadrangle parallel to Pine Mountain and bounded roughly on the northwest by the base of the mountain and on the southeast by Pound River. Along the river it dips beneath younger rocks and is under cover as far as Cranes Nest River and Birchfield Creek, where it is again exposed, forming the lower part of the valley walls. There is also a narrow area along the upper course of Indian Creek. The formation disappears beneath Sand Ridge and Black Mountain and is concealed in the southern part of the quadrangle, but it outcrops several miles south of the quadrangle along the southern margin of the coal field.

Correlation of Coal Beds.

The correlation of the Norton coals of this area with the Norton coals of the southern margin of the Virginia coal field as classified by Campbell[1] is more fully discussed on page 19 and only a brief statement of conclusions need be given here. The coal bed at a point 190 feet above the bottom of the Norton formation is the Jawbone, the one at 320 feet is the so-called Imboden, the coal at 410 feet apparently does not appear in the Bristol section, the coal at 560 feet is equivalent to the Widow Kennedy bed, and the coal bed at 730 feet above the bottom of the formation is the Lower Banner bed. The Upper Banner coal is not present unless it is represented by the group of thin coals 250 to 270 feet below the Gladeville sandstone, including the 7-foot bed in well No. 15, east of the quadrangle.

[1]Campbell, M. R., Geology of the Big Stone Gap coal field of Virginia and Kentucky; U. S. Geol. Survey Bull. 111, pp. 33–36, 1893; U. S. Geol. Survey, Geol. Atlas, Estillville folio (No. 12), 1894; Bristol folio (No. 59), 1899.

The Edwards-Imboden horizon is represented by another group of thin coals 150 feet below the Gladeville sandstone. The coal just below the Gladeville sandstone appears to be the Yellow Creek bed mined east of Wise, 2 miles south of this quadrangle.

Nearly all the coal beds of the Norton formation, except the thick bed in boring No. 15 (Pl. I), are less than 3 feet thick, and most of them are less than 2 feet thick. Several of the bore-hole sections show a number of thin coal streaks associated with the thicker beds, and this suggests that owing to rapid sedimentation the continuity of accumulation of vegetal matter in this area was more or less interrupted during the period of coal formation, and that such conditions resulted in the deposition of a number of thin beds instead of one thick bed, such as occurs at the same horizon at Toms Creek, Norton, etc., along the southern margin of the Virginia coal field, although the total accumulation of vegetal matter may have been about equal in both areas.

GLADEVILLE SANDSTONE.

The Gladeville sandstone was named by Campbell from Gladeville, now Wise, a town 2 miles south of the quadrangle, which is built on the sandstone. It underlies Sand Ridge and is exposed on Steele Fork of Cranes Nest River, on Cranes Nest River, and on Birchfield and Indian creeks. It underlies Bowlecamp Knob, and a few feet of the top of the stratum outcrops along Mullin and Dotson forks of Bowlecamp Creek as far as Pound River. It is also exposed on Camp Creek and Georges Fork. The outcrop follows the general course of Pound River across the quadrangle, the sandstone rising northwestward toward Pine Mountain and underlying only the higher knobs near the river. It is a very persistent bed and exceedingly serviceable as a key rock. On the map its outcrop is shown by the stipple pattern between the lines representing the outcrops of the Glamorgan and Yellow Creek coal beds or their horizons.

At Wise the Gladeville sandstone is hard, white, and siliceous and appears to be about 100 feet thick. In the region north of Sand Ridge, however, it is less purely siliceous and thinner than at Wise; it contains more argillaceous matter and more feldspar and mica, and its thickness does not exceed 60 feet.

WISE FORMATION.

The Wise formation includes the mass of shale and sandstone 2,070 feet thick, including many coal beds, lying between the Gladeville sand-

stone below and the Harlan sandstone above. It includes at least nineteen distinct coal beds and probably others that have not yet been discovered. The Wise formation constitutes the surface rock in most of that portion of the quadrangle lying south of Pound River. North of the river it also caps some hills and ridges, and southeast of Birchfield Creek it occurs only on the hills, the Norton formation outcropping in the valley bottoms and well up on the hillsides.

Glamorgan coal.—Immediately above the Gladeville sandstone is the Glamorgan coal, named from Glamorgan, just beyond the south margin of the quadrangle, where the bed is mined. It attains its maximum known thickness in the hills south of the heads of Birchfield Creek and Dotson Fork, northeast of Glamorgan. On Birchfield Creek and Dotson Fork the bed is divided by partings, but generally includes one bench 2 feet or more thick. Along Pound River northeast of Pound a persistent thickness of 2½ to 3 feet is shown at numerous openings, but here also the bed contains several partings.

Above the Glamorgan coal is 200 feet of shale and sandstone containing five coal beds. The sandstone is highly siliceous, hard, and white and differs in these respects from the prevailing type of sandstone in this region, which is softer and more highly feldspathic and micaceous. The sandstone bed at the top, just above the uppermost of the five coal beds (Clintwood coal) and in places in contact with that bed, is especially noteworthy, for it is persistent over a large area and either outcrops as a ledge or makes a distinct shelf along the hillside, by which the position of the outcrop of the underlying coal can be determined. All these sandstones and associated coal beds are exposed along the road on Guests River from the south margin of the quadrangle to a point 1½ miles north of Lipps. The first important coal bed above the Glamorgan occurs 60 feet above the Gladeville sandstone. The bed is 2 feet or more thick and appears to persist over the southeastern quarter of the quadrangle.

Blair coal.—About 40 feet above the bed last described is a coal bed here named the Blair, because it has been opened by a man of that name on Lick Branch of Indian Creek 3 miles above the mouth. This coal is also persistent in the southeastern part of the quadrangle and appears to range from 2 to 5 feet in total thickness.

Clintwood coal.—One hundred feet above the Blair coal, or 200 feet above the Gladeville sandstone, is the Clintwood coal, named from the town of Clintwood, about 1½ miles east of the quadrangle. On Georges Creek and Lick Fork of Cranes Nest River the Clintwood is 6 to 12 feet thick,

including partings; elsewhere it is thinner, though persistent throughout the quadrangle. As noted above, everywhere in the quadrangle the Clintwood is overlain by a sandstone 20 to 40 feet thick, which either rests upon the coal bed or is separated from it by only a few feet of shale.

Above the sandstone just mentioned there is in certain localities a coal bed reaching 2 feet in maximum thickness. It is succeeded by 150 to 200 feet of soft shale, which over a large area is followed by 50 feet or so of coarse feldspathic and micaceous sandstone.

Bolling coals ("Five-foot bed").—At the top of the coarse micaceous sandstone, or about 250 feet above the Clintwood coal, is the lower of two coal beds separated by 20 to 40 feet of shale. The upper coal bed is designated the "Five-foot bed" on the outcrop maps of the Clinchfield Coal Corporation, but the name Bolling is here applied to both beds because they have been opened near the head of Pound River by several persons of that name. The Lower Bolling coal is 18 inches to 4 feet thick and the Upper Bolling is 18 inches to 5 feet thick. These coal beds underlie Black Mountain, Buck Knob, and Bowlecamp Knob, and their horizon is a little below the tops of several knobs and ridges in the southeast corner of the quadrangle. Above the Upper Bolling is 50 to 80 feet or more of coarse micaceous sandstone which for long distances outcrops as a low cliff or forms a low escarpment. This sandstone persists throughout the area underlain by the Bolling coals. On South Fork of Pound River the coarse sandstone is overlain by about 140 feet of shale and sandstone, capped by a 40-foot bed of sandstone.

Standiford coals.—Within 100 feet above the Bolling coals are one or more thin coal beds, and about 260 feet above these coals are two beds 20 feet apart, which are here called the Standiford coals because they are mined near the head of South Fork of Pound River by a man of that name. At the type locality the Lower Standiford coal is 2 feet 6 inches and the Upper about 3 feet thick. These coals appear to underlie the Black Mountain and Buck Knob region, but it is probable that they have been removed by erosion in the country farther east except possibly in a small area near the top of Bowlecamp Knob.

Taggart coal.—On South Fork of Pound River the 90 to 100 feet of beds above the Standiford coals are apparently for the most part sandstone, at the top of which are two coal beds, separated by 6 feet of shale, the upper bed 3 feet and the lower 2 feet 6 inches thick. On Roaring Fork of Powell River the name Taggart is applied to a bed believed to be the equivalent of this double bed, and that name is adopted here. On Roaring

Fork the bed, which has been thoroughly prospected, is double at some points, and one section examined by the writer has four coal beds in a space of about 75 feet, as shown in section 98 (page 46). It is supposed that at least the upper two beds of this section, which are separated by 20 feet of shale and sandstone, represent the Taggart horizon. At most points where this coal has been prospected only one bench is recorded, either because only one bench is present or because only one of two or more benches possibly present was discovered.

Low Splint coal.—The name Low Splint is applied to a coal bed about 200 feet above the Taggart on the head of Roaring Fork. At the head of South Fork of Pound River is a bed, 160 feet above the Taggart, opened on the George Phillips place, which is correlated with the Low Splint. It appears to be persistent and to range in thickness from 2½ to 4 feet, but being high in the hills it is present only in Black Mountain and Buck Knob. It is probably the Buck Knob bed of the Clinchfield Coal Corporation.

Phillips coal.—The Low Splint bed is succeeded by 260 feet of shale and sandstone in which no coal was seen in this region and at the top of which is a coal bed named the Phillips coal, because it has been opened at the Ambrose Phillips place, at the head of South Fork of Pound River, where it is reported to be 26 inches thick and to be all coal.

In the 390-foot interval between the Phillips and the Pardee coal beds at the head of South Fork of Pound River are shale and sandstone with thin coal beds as follows: At 80 feet above the Phillips is an 18-inch bed of coal, 210 feet above is a 1-foot bed, 225 feet above is a 2-foot bed, and 340 feet above the Phillips, or 50 feet below the Pardee bed, is a 6-inch coal. Between 210 and 225 feet above the Phillips coal is an 8-inch limestone bed, which is the only limestone seen in the entire Pennsylvanian section except some nodules in the shales on Elkhorn Creek in Kentucky.

Pardee (Limestone) coal.—At 390 feet above the Phillips bed, or 1,670 feet above the Gladeville sandstone, is the Pardee bed, which is mined at Pardee, just west of the southwest corner of the quadrangle. This is the Limestone coal bed of the Kentucky Geological Survey reports and the Parsons bed of the Virginia Coal and Iron Company. At Pardee and for a mile or two to the east within the Pound quadrangle the bed contains about 10 feet of solid coal, but farther east and northeast it is in places divided by thick partings into two or three benches. It is 2,800 to 3,100 feet above sea-level, and, therefore, lies near the summit of Black Mountain and its radiating spurs. Above the Pardee bed is about 100 feet of shale overlain by rather coarse grained but flaggy sandstone 300 feet thick.

High Splint coal.—The High Splint coal is 400 feet above the Pardee bed and is a genuine splint coal 4 to 5 feet thick. It is so high in the hills that it underlies only a small area on Black Mountain.

HARLAN SANDSTONE.

Above the High Splint coal appears to be several feet of shale, overlain by a massive cliff-making sandstone, in places conglomeratic, which is 40 feet thick and which is taken as the basal stratum of the Harlan sandstone. Extending from the High Splint coal bed to the top of the highest summits of Black Mountain, the Harlan sandstone is a little over 400 feet thick. It is mostly coarse, thick-bedded to massive sandstone but contains shale beds and at least two coals of unknown thickness, fragments only being seen at two places. One of these coal beds is 100 feet and the other 300 feet above the High Splint bed.

General Correlation.

From incomplete paleobotanic studies, David White refers all the coal measures of Virginia and easternmost Kentucky and the region extending southwestward into Alabama to the lowest division or Pottsville group of the Pennsylvanian series. The type locality of the Pottsville group is Pottsville, in the southern anthracite field of Pennsylvania. The Pottsville is for convenience subdivided by White into lower, middle, and upper Pottsville, the subdivisions being based primarily on the presence in each of certain distinctive species of fossil plants. Some of the subdivisions of the Pottsville may be distinguished over large areas by lithologic character—as, for example, the Lee formation in Virginia and Tennessee, which is shown by paleobotanic evidence to coincide nearly if not completely with the lower Pottsville. In certain places, where the subdivisions are not lithologically distinct, the boundary between any two may be marked by a particular stratum which is widely identifiable. This is especially true where one of the formations marks an extension of the sea over the land. Thus throughout the southern part of the Virginia and West Virginia coal fields the boundary between the lower and middle Pottsville as paleobotanically determined is approximately marked by the Raleigh sandstone. Where lithology fails as a criterion for fixing boundaries or where occurrences are, as in coal fields or separate basins, far apart, it is necessary to resort to the evidence afforded by the fossil plants.

The probable stratigraphic equivalence of the Pottsville formations and coal beds in the Pound quadrangle to those of other areas along the eastern

border of the Appalachian coal fields is indicated in the plate of sections, Pl. II. In this table the correlations of formations and beds between districts or basins outside of the vicinity of the Pound quadrangle are based on partial studies of the fossil floras by White[1] and are regarded by him as provisional and subject to revision when either the paleobotanic material of the formations is more completely studied or, where possible, the beds are stratigraphically traced from point to point in detail and the depositional characteristics of the formations are more fully recognized. The correlations of the formations and beds in and near the Pound quadrangle are made by the present writer.

As already noted, the Lee formation is of lower Pottsville age. This formation extends southwestward into Tennessee and is equivalent to the Lookout and the greater part of the Walden sandstone of southern Tennessee. On the northeast the Lee corresponds to the Pocahontas, Welch, and Raleigh formations of the Tazewell quadrangle; the Pocahontas, Clark, Quinnimont, and Raleigh formations of the Pocahontas quadrangle; the Thurmond, Quinnimont, and Raleigh formations of the Raleigh quadrangle, and approximately to the lower 800 feet of the Pottsville of the southern anthracite field of Pennsylvania, including the "Lykens No. 4" coal.

The Norton formation is classed by White as middle Pottsville, and the overlying Gladeville sandstone is regarded by him as probably near the horizon of the Corbin conglomerate lentil of the Lee formation as the strata are mapped in the London (Ky.) folio, covering an area 75 miles due west of the Pound quadrangle. The Gladeville seems to represent the Slater sandstone member of the Mingo formation of the Cumberland Gap region and lies within the limits of the Wartburg sandstone in the Wartburg quadrangle, Tennessee. On the northeast the Gladeville is supposed to be represented by the Dotson sandstone of the Tazewell quadrangle and the Nuttall sandstone lentil at the top of the Sewell formation in the Raleigh quadrangle. The Sharon conglomerate member of the Pottsville (upper Pottsville) of western Pennsylvania is also regarded as lying at about the same stratigraphic horizon, though it may possibly be higher. While it is not maintained that the sandstone beds at the different points named are parts of one continuous stratum or that they are at exactly the same stratigraphic horizon and of precisely the same age, it is fairly well established on stratigraphic and paleobotanic grounds that they do not vary greatly from the same horizon and age throughout.

[1] U. S. Geol. Survey, Prof. Paper 71, pp. 444-445, 1912.

Southwest of the Virginia coal field the Norton formation is represented by beds between the Rockcastle conglomerate member and the base of the Corbin conglomerate lentil of the Lee formation as mapped in the London folio, by the Hance and the lower three-fifths of the Mingo formation of the Cumberland Gap region, and by the Briceville shale and possibly by the lower part of the Wartburg sandstone of the Briceville and Wartburg quadrangles, in Tennessee. On the northeast the Norton is correlated with the Dismal and Bearwallow formations of the Tazewell quadrangle; with all of the Sewell formation below the Nuttall sandstone member in the Raleigh quadrangle; and with that part, 200 feet thick, of the Pottsville of the southern anthracite field extending roughly from 370 to 570 feet below the Buck Mountain coal bed and including near the middle the Lykens coal beds Nos. 2 and 3.

The Wise formation is shown by its fossil plants to be of upper Pottsville age. It contains the greater part at least of the Breathitt formation of the London quadrangle, Kentucky. It also includes the Bryson, Hignite, and Catron formations and probably the upper two-fifths of the Mingo formation of the Cumberland Gap field, and the upper part of the Wartburg, the Scott, and at least the greater portion of the Anderson formations of the Wartburg and Briceville quadrangles. Beds of Wise age are included in the Sequoyah and Tellowa formations of the Tazewell quadrangle, the Kanawha formation of the Raleigh quadrangle, and the upper 370 feet of the Pottsville of the southern anthracite field. The Kanawha formation, which, together with the Nuttall sandstone member of the Sewell formation, presents the most typical section of the upper Pottsville, apparently contains also, in southern West Virginia, the equivalent of the lower part of the Harlan sandstone of the Estillville quadrangle.

GEOLOGIC STRUCTURE.

As used here the term geologic structure means the attitude and arrangement of the rocks considered as extensive strata composing the earth's crust. Stratified rocks are deposited in a nearly horizontal attitude. In most of the Pound quadrangle, however, they are not now horizontal but very gently inclined, while in some places, as along the west escarpment of Pine Mountain, they dip steeply. There are also breaks, called faults, which extend to great depths and along which the strata on one side have been raised to higher levels than the corresponding strata on the other side or even thrust clear over on top of them.

Pine Mountain fault.—The Pine Mountain fault is the major structural feature of the region. It extends in a nearly straight line diagonally across the quadrangle near but somewhat above the west base of Pine Monntain in Kentucky. The fault is compound. There are two breaks, which, for the purpose of description, may be considered as having occurred at different times. By the earlier break a thin wedge of conglomeratic sandstone of the Lee formation, extending from the west side of the quadrangle northeastward to the vicinity of Jewel, at the mouth of Marshall Branch, was thrust into contact with rocks 1,200 feet higher than the top of the Lee. Also in the northwest corner of the quadrangle and extending a mile beyond its edge is a mass of hard siliceous conglomeratic sandstone of the Lee in a vertical attitude which has been pushed, probably by the earlier fault, half a mile westward over the flat-lying rocks stratigraphically 1,000 feet or more above the top of the Lee. Later another break occurred along which the displacement varies. On the west side of the quadrangle the Mississippi part of the Grainger shale is in contact with the wedge of the Lee formation brought up by the earlier fault; three miles east of the west margin the fault brings the Devonian black shale into contact with the Lee, and in the northwest quarter of the quadrangle the movement was so great that the upper 800 feet or so of the black shale has been thrust clear over the earlier fault plane and is in contact with Pennsylvanian rocks 2,000 feet above the base of the Lee, the total displacement here being about 4,000 feet. Sections A B, C D, E F, Pl. III, illustrate the structural and stratigraphic relations brought about by these faults.

Pound syncline.—From Pine Mountain the rocks dip southeastward to an axis that follows the general course of Pound River and is named the Pound syncline. The southeastward dip on the west escarpment of Pine Mountain is generally steep, but ranges from 20° to nearly vertical. Along the crest of Pine Mountain the dip is 20° to 40°; at the east base it is 10°, and thence it diminishes gradually to zero at the axis of the Pound syncline.

Buck Knob anticline and Indian Creek syncline.—In the southeastern part of the quadrangle, south of the Pound axis, the rocks have a general northwest dip toward that axis, but this general dip is interrupted by a subordinate anticline that extends nearly north and south through Buck Knob and is called the Buck Knob anticline. The existence of this low anticline involves a corresponding syncline, here named the Indian Creek sycline, the axis of which is parallel to the anticline and to Indian Creek, lying from half a mile to 1 mile to the west. On the east side of this

syncline steep dips occur locally. At Glamorgan the dip is 10° W., and three-quarters of a mile farther north, at the intersection of the highway with the tramroad, it is 40° W. On the west side of Indian Creek, 5 miles above the mouth, the Clintwood coal and overlying sandstone dip 10° W. On the Buck Knob axis north of the knob the Bolling coals are about 2,200 feet above the sea; on the Indian Creek axis they are about 2,000 feet, the eastward dip being 200 feet in 2 miles; on the Pound axis west of Dewey the same coals are about 1,900 feet above the sea, giving a westward dip from the Buck Knob to the Pound axis of 300 feet. Apparently both the Indian Creek and Buck Knob folds flatten out and become imperceptible east of Dewey. Both axes rise toward the south, but maintain the same relative height in the quadrangle, the Bolling coals on the south margin being, as nearly as can be determined, 2,700 feet above sea level on the Buck Knob anticline and 2,500 feet in the Indian Creek syncline.

Summary.—Aside from the comparatively minor effect of these subordinate axes, the general structure of the Virginia part of the quadrangle is that of a broad and comparatively shallow unsymmetrical trough. At the southeast corner of the quadrangle the Gladeville sandstone is 2,500 feet above the sea, and it descends thence to about 1,500 feet above the sea along the Pound axis, the average dip being about 1°. Along the crest of Pine Mountain the Gladeville would, if restored, lie 5,000 feet above the sea, so that the total descent is 3,500 feet from the crest of the mountain to the axis of the Pound syncline, an average dip of 18°.

DETAILED DESCRIPTION OF COAL BEDS.

A comprehensive idea of the number, thickness, and sequence of the coal beds in the Virginia part of the Pound quadrangle can be obtained by an examination of the generalized columnar section (Pl. III).

Coals of the Lee Formation.

In this area very little is known of the coal of the Lee formation, which outcrops only along the southeast slope of Pine Mountain, being elsewhere deep beneath overlying formations and penetrated at only one point by a diamond-drill boring. On the outcrop along the eastern slope of Pine Mountain the surface is heavily timbered. No prospecting appears to have been done in this forbidding belt, and as natural exposures, if any, of the coal beds are rare, the chance of examining the beds is very remote indeed. Only in the Pound Gap road, where the Lee has been exposed in road making and by the wear incident to a highway, was any coal seen in outcrop.

However, considerable coal is known to exist in the Lee in beds 14 inches or more thick and at a depth not exceeding 2,000 feet. The most definite knowledge of the number, thickness, and stratigraphic relations of these beds is derived from the record of a drill hole on Cranes Nest River 1 mile east of the quadrangle, a short distance below the mouth of Lick Fork. (See Pl. I, section 1, in which details of the beds are shown.) In this well a coal 2 feet 6 inches thick is shown to lie near the base of the Lee formation, and eight beds 2 inches to 2 feet 2 inches thick are shown within the Lee. Six of these beds are grouped in the 300 feet just below the middle of the formation. As shown in the plate of correlation sections (Pl. II), the Pocahontas coal appears to be represented in this group of beds.

On the Pound Gap road five beds are exposed. In the well section the greater number of beds is grouped just below the middle of the formation; in the road section the greater number, so far as shown, seems to be rather above the middle of the formation.

The lowest bed, imperfectly exposed in the Pound Gap road section 500 feet east of the summit, at location No. 1[1], is about 200 feet above the base of the Lee and seems to be 2½ feet thick. Farther down on the east slope of the mountain, in the vicinity of the abandoned narrow-gage railroad station, four beds are exposed at stations Nos. 2, 3, 4, and 5. At No. 2 the following section was measured:

Section of coal bed on Pound Gap road, No. 2.

	Ft.	in.
Coal, dirty		6
Clay		1
Coal, dirty		8
Clay, white.		
	1	3

At No. 3 just at the old railroad station the section is as below.

Section of coal bed at narrow-gage railroad station on Pound Gap road, No. 3.

	Ft.	in.
Shale and sandstone	10	
Clay, carbonaceous		7
Coal		3
Clay, carbonaceous		2
Coal		2
Shale	20	

[1]Numbers refer to locations on the map.

The carbonaceous clay at this point is crowded with fern pinnules.

Five hundred feet nearly east of station No. 3, at No. 4, a bed has been prospected superficially and 18 inches of clean coal was seen. This bed is probably but a short distance above the bed at No. 3. At location No. 5, near No. 4, another bed 3 inches thick and 20 feet above the bed at No. 4 is exposed.

COALS OF THE NORTON FORMATION.

The coal beds of the Norton formation are the principal beds mined along the southern margin of the Virginia coal field from Dump Creek to Big Stone Gap, but in the Pound quadrangle they are not so well developed as farther south, as is shown by diamond-drill borings in the southeast quarter of the quadrangle and by the few exposures known along the outcrop of the formation between Pound River and Pine Mountain.

Sections of the diamond-drill borings are shown on Plate I (p. 7). The wells are too few and too widely separated to give full information regarding the coal beds, but they seem to afford a fairly reliable indication of the general condition and possibilities of the Norton coals in the eastern half of the quadrangle. They reveal numerous coal beds, but most of the beds are only a few inches thick. Every well, however, shows one or more beds 14 inches or over thick and less than 1,000 feet below the surface. In a few wells thicker beds were penetrated, as a bed 2 feet 10 inches thick at a depth of 629 feet in well No. 2; one 4 feet 3 inches thick at 832 feet in well No. 3; one 2 feet 5 inches thick at 847 feet in well No. 11; and one 7 feet 1 inch thick at 351 feet in well No. 15, which is, however, 2 miles east of the quadrangle. Details of the section of the thicker beds are shown in the figures. The ultimately workable coal is therefore considerable, although such coal will not be available until after the thicker and more accessible coal beds of the country are exhausted.

The identification of the individual coal beds of these sections and their correlation with the coals of the Norton formation along the southern margin of the field, where the beds seem to be more constant in number and position, are rather uncertain. For the purpose of comparison with the better-known section to the south the generalized (average) section from the Bristol folio is given on Plate I. The tentative correlations are indicated by the broken lines on the plate of sections. The sections are arranged on the horizon of the bottom of the Gladeville sandstone, which is identified throughout the region with a reasonable degree of certainty. All the coals recognized in the Bristol region appear to be present in the

Pound quadrangle, except, perhaps, the Upper Banner, which is the most valuable bed in the Bristol quadrangle. The Jawbone and so-called Imboden beds appear to be persistent but thin. Two persistent beds 100 feet apart occur near the Kennedy horizon and it is uncertain which is the true Kennedy. The Lower Banner is persistent and at some points is of considerable thickness, as in boring No. 3. It is more generally thin or so broken by partings as to be worthless. In borehole No. 3 the section is as follows:

Section of Lower Banner coal in drill hole No. 3, Birchfield Creek.

	Ft.	in.
Shale.		
Coal	3	6
Clay		3
Coal		6
	4	3

In boring No. 8 the bed is 3 feet 6 inches thick but is intimately mixed with shale and worthless.

It is possible that the persistent group of thin coals below the Edwards coal or group represents the Upper Banner, which is separated from the Lower Banner by more than twice the thickness of rocks separating the two beds on the southern outcrop of the Norton formation. If this rather doubtful supposition is correct, the 7-foot bed in boring No. 15 might be regarded as representing the Upper Banner coal.

The upper group of thin beds represents the Edwards or true Imboden horizon. In boring No. 3 this group is 3 feet thick, with a thin parting; elsewhere it is widely parted.

At only a few points in the quadrangle or just outside its eastern and western margins were exposures of any of the coals of the Norton formation seen. On Rumley Creek about 2 miles north of Flat Gap postoffice, at location No. 6, a bed of clean coal 2 feet thick has been opened and worked on a small scale. About 2 miles south of Osborne Gap, toward the east side of the quadrangle, at locations Nos. 7, 8, and 9, coal is exposed indicating beds 18 inches in thickness; and about 1 mile farther east, at No. 10, is a blossom indicating a thin coal. All these coals seem to be in the lower half of the Norton formation. On Cumberland River half a mile beyond the western margin of the quadrangle a bed 30 inches thick, all coal, has been worked on the Ira Sturgill place. On Pine Creek three-fourths of a mile west of the east boundary of the quadrangle, at location No. 11, a bed 1 foot 9 inches thick is exposed at creek level. These out-

crops are apparently about in the middle of the Norton formation and the bed possibly represents one of the Banner coals.

On the North Fork of Pound River about 1 mile west of Donkey (No. 12), a bed is opened having the following section:

Section of coal bed 1 mile west of Donkey, No. 12.

	Ft.	in.
Shale.		
Coal		10
Bone		3
Coal	1	9
Sandstone.		
	2	10

At station No. 13, half a mile west of No. 12, two thin coal streaks are exposed in the bottom of a ravine. These coals appear to be 150 to 200 feet below the Gladeville sandstone and thus at the Edwards or Imboden horizon.

Yellow Creek coal.—Half a mile beyond the western margin of the quadrangle a coal just under the Gladeville sandstone shows the following section:

Section of Yellow Creek coal bed on Cumberland Valley Road.

	Ft.	in.
Sandstone.		
Coal		5
Clay		1
Coal	2	4
Clay.		
	2	10

The same bed is exposed at the schoolhouse a mile west of Flat Gap (No. 14), where the section is as given below:

Section of Yellow Creek coal bed at schoolhouse on Cumberland River one-half mile west of Flat Gap, No. 14.

	Ft.	in.
Sandstone.		
Coal		5½
Shale		2
Coal		9
Clay.		
	1	4½

The same bed has also been opened on a branch 1 mile northeast of Flat Gap postoffice (No. 15) but could not be seen. It has also been

exposed in grading the railroad along North Fork of Pound River 2 miles southwest of Donkey, at No. 16, where it has the following section:

Section of coal bed 2 miles southwest of Donkey, No. 16.

	Ft.	in.
Coal	1	1
Clay		1½
Coal		6
	1	8½

This bed is in the position of the Yellow Creek coal mined at Wise.

The only other locality at which Norton coals are known in outcrop sufficiently near this quadrangle to be considered here is on the new road between Wise and Clintwood 1½ miles south of Cranes Nest River, one-third of a mile east of the quadrangle, where the coals have been exposed in grading. Nine coal beds are exposed in a vertical distance of about 350 feet below the Gladeville sandstone, but only one bed, at about 250 feet below the sandstone, is of much importance. Its section is given below.

Section of coal on new Wise-Clintwood road about 2 miles south of Cranes Nest River.

	Ft.	in.
Shale.		
Coal		10
Clay		4½
Coal	1	6
Sandstone floor.		
	2	8½

Most of the other beds are thin and worthless. This section is in full agreement with the upper part of the diamond-drill sections.

The facts in hand appear to warrant the conclusion that while the Norton coals of this quadrangle are of less value than those along the southern margin of the Virginia coal field, there are yet considerable areas of workable coal in the various beds known by drilling to underlie the area. Exploitation of these coals, however, can be safely undertaken only after the location and extent of the workable areas have been determined by thorough prospecting with the diamond drill.

Coals of the Wise Formation.

The Wise formation contains a greater amount of coal in workable beds than any of the other formations of the quadrangle. The Wise and all its

coal beds are present in full thickness only in Black Mountain, in the southwest corner of the quadrangle, because a progressively greater thickness of the formation has been eroded eastward from that area.

Glamorgan coal.—Immediately above the Gladeville sandstone is the Glamorgan coal bed, named from the town of Glamorgan, just south of the quadrangle. opposite the head of Indian Creek, where it is mined. The bed is best developed in the hills north and northeast of Glamorgan. In the Glamorgan mine, which extends 7,000 feet northeastward toward Birchfield and Dotson creeks, the bed is divided into two benches by a parting which is a quarter of an inch thick at 7,000 feet from the mouth, 1 inch thick at 6,000 feet, 10 feet or so at 1,000 feet, and 30 feet at the mine mouth. At 7,000 feet from the mine mouth the bed has the following section:

Section of Glamorgan coal bed in the Glamorgan mine 7,000 feet from mouth.

	Ft.	in.
Shale roof.		
Coal (¼-inch parting near middle)[1]	3	8
Bone		1
Coal[1]		7
Shale.		
	4	4

Section in same mine 6,000 feet from mouth.

	Ft.	in.
Shale roof.		
Coal[2]	1	9
Bone		1
Coal[2]	1	10
Bone		1½
Coal[2]		8
	4	5½

[1]Included in sample for analysis No. 15101, p. 54.
[2]Included in sample for analysis No. 15100, p. 54.

On account of the split described above only the lower bench of the bed is mined in the first 1,000 feet along the main entry of the Glamorgan mine, and nowhere else in the quadrangle is the bed known to be as thick as in the deeper part of the mine. On the new Wise-Clintwood road near the eastern margin of the quadrangle (No. 17) the bed is 2 feet 1 inch thick.

On Indian, Dotson, and Birchfield creeks and on the forks of Bowlecamp Creek the Glamorgan coal is 1 foot 6 inches to 2 feet 6 inches thick including partings.

On Birchfield Creek 2 miles above the mouth of Dotson Fork, at locations Nos. 18 and 19, the bed is 1 foot 9 inches and 2 feet 4 inches thick respectively. On the west side of Indian Creek three-fourths of a mile below Riley School (No. 20) the bed has been opened and shows the following sections:

Section of Glamorgan coal on Indian Creek three-fourths of a mile below Riley School, No. 20.

	Ft.	in.
Shale.		
Clay with coal streaks		4
Coal	2	
	2	4

The clay with coal streaks in the roof is a common characteristic of the bed northeast of Pound.

Along the lower course of Indian Creek, in the vicinity of Pound, and on the lower courses of the three forks of Bowlecamp Creek the Glamorgan bed is split up into two or three thin beds of no value. Toward the head of Dotson Fork of Bowlecamp Creek (Nos. 21 and 22) it is in better condition, as shown by the following sections, which show also its variability within short distances:

Sections of the Glamorgan bed near the head of Dotson Fork of Bowlecamp Creek, Nos. 21 and 22.

No. 21.

	Ft.	in.
Shale.		
Coal	1	6
Shale	8	
Coal		6
Interval	2	
Sandstone (Gladeville).		

No. 22.

	Ft.	in.
Sandstone.		
Coal	2	2½
Shale		2
Coal		2
Clay.		
	2	6½

The bed was not seen along the lower part of Birchfield Creek or on Lick Fork, though its presence in the vicinity of Kilgores is revealed by prospect pits, Nos. 23 and 24, in which a thin bed is indicated.

Northeast of Pound along Pound River and on Georges Creek the bed is of workable thickness, as shown by sections Nos. 25 to 28.

Section of Glamorgan coal on Mill Creek 1 mile northeast of Pound, No. 25.

	Ft.	in.
Shale.		
Coal		6
Clay	1	2
Coal		10½
Bone		2
Coal		3
	2	11½

Section of Glamorgan coal on Georges Fork, No. 26.

	Ft.	in.
Shale.		
Coal		5½
Bone		1½
Clay		1
Coal	1	
Clay		1
Coal		8½
Clay.		
	2	5½

Section of Glamorgan coal on Camp Creek near mouth, No. 27.

	Ft.	in.
Shale.		
Coal		6½
Clay	1	4
Coal	3	2
Clay		½
Coal		¾
Clay.		
	5	1¾

Section of Glamorgan coal one-half mile north of Pound River opposite the mouth of Camp Branch, No. 28.

	Ft.	in.
Shale.		
Coal		3
Rash		2
Coal	2	4
Clay.		
	2	9

These sections indicate the range in the thickness and make-up of the bed in this part of the quadrangle. It shows improvement northeastward as far as Freeling, a mile or so east of the quadrangle.

Along the North Fork of Pound River southwest of Pound to a point within 2 miles of Flat Gap post office the presence of the Glamorgan coal is shown by several exposures and openings, but so far as definite knowledge of it could be obtained it is not of workable thickness.

Coal bed 50 to 70 feet above the Gladeville sandstone.—From 50 to 70 feet above the Gladeville sandstone is a coal bed that is generally 2 feet or a little more in thickness over a considerable area. This bed is known on Guests River for a mile north of the quadrangle boundary, on the South Fork of Pound River to the vicinity of Dewey, on the forks of Bowlecamp Creek, and along the new Wise-Clintwood road. On the North Fork of Pound River 2 miles north of Dewey (No. 29) the bed is 2 feet thick. Three-fourths of a mile northeast of Dewey (No. 30) the bed has the section shown below.

Section of coal three-fourths of a mile north of Dewey, No. 30.

	Ft.	in.
Shale.		
Coal (dirty)		4
Coal (clean)	1	3
Coal (bony)		7
Clay.		
	2	2

At Glady School, at the mouth of Glady Creek (No. 31), the following section was measured.

Section of coal at Glady School, No. 31.

	Ft.	in.
Coal		10
Shale		2
Coal	1	8
Coal (bony)		6
	3	2

Along South Fork of Pound River between Glady School and Donkey at least four coal beds appear at about the horizon of the bed here described and render identification doubtful. This condition is illustrated in the section following.

Section showing coal beds on South Fork of Pound River about midway between Glady School and Donkey, No. 32.

	Ft.	in.
Coal	2	
Interval	10	
Coal		6
Interval	10	
Coal		6
Interval	8	
Coal	1	1+
	32	1

Possibly the upper coal in this section is the Blair bed, next to be described. The two 6-inch beds may be splits from either the Blair bed or the bed next above the Glamorgan, described under this head, while the bottom bed represents the main bench of that bed.

At the Widow Short place (No. 33) the following section was obtained.

Section of coal beds at the Widow Short place on the South Fork of Pound River midway between Glady School and Donkey, No. 33.

Sandstone.	Ft.	in.
Coal	2	4
Shale	11	
Coal (impure)		4
Shale		3
Coal	1	6
	15	5

Here again there is doubt as to the interpretations of the section. It is possible that the bed here described and the Blair bed next above have approached within 11 feet of each other.

On Mullins Fork 2½ miles above the mouth, at location No. 34, the bed under discussion seems best developed as shown by the section below.

Section of coal on Mullins Fork two and one-half miles above its mouth, No. 34.

Shale.	Ft.	in.
Bone		6
Coal	1	3
Clay	1	2
Coal	1	10
	4	9

At this point this coal is 70 feet above the Gladeville sandstone and 30 feet below the Blair coal.

Near the head of Dotson Fork of Bowlecamp Creek (No. 35) the bed is 38 inches thick and consists of clean coal. On the new Wise-Clintwood road, at locations 36 and 37, the bed has an upper bench of coal 1 foot 6 inches thick and a lower bench 1 to 2 feet thick made up of thin coal streaks and clay partings. On Lick Fork and Georges Fork this bed was not recognized.

Near the head of Dotson Fork of Birchfield Creek (No. 38) a bed that is doubtfully referred to this horizon has been opened. Its section is as follows.

Section of coal bed near the head of Dotson Fork, No. 38.

	Ft.	in.
Shale.		
Coal	2	3
Clay		8
Coal		5
Shale.		
	3	4

On Guests River between Lipps and a point 1 mile northwest along the road there are five coal beds dipping northward and passing in succession below road level. By projecting the beds into a plane as nearly as may be according to the dip the following section is obtained.

Section showing coal beds along Guests River road for 1 mile north of Lipps.

	Ft.	in.
Coal (reported thickness)	2	
Sandstone, hard siliceous	20	
Interval not exposed	20	
Coal (Clintwood?)	2	
Sandstone	10	
Shale	10	
Coal (Clintwood split?)	2	3
Sandstone	15	
Interval not exposed	10	
Sandstone	5	
Interval not exposed	20	
Coal (Blair coal?)	2+	
Sandstone (partly hard, siliceous)	40	
Coal (reported thickness 3½ feet, next above Glamorgan bed), seen	2	
	160	3

This section includes the group of coal beds between the Gladeville sandstone and the Clintwood bed (described on page 10), except that it does not go down to the Glamorgan coal. That bed, however, shows in the road at the quadrangle boundary half a mile south of Lipps.

The coal next above the Glamorgan bed is opened at Lipps (No. 39), but the opening is partly closed. Two feet of solid coal was seen and the bed is reported to be 3½ feet thick.

Blair coal.—On Lick Branch of Indian Creek 3 miles above its mouth a coal bed of good thickness has been opened on the Blair property and is therefore named the Blair bed. In the southeastern part of the quadrangle this bed is 2 to 5 feet thick, including partings. Below is a section of the bed at the Blair opening (No. 40).

Section of Blair coal at Blair opening near Indian Creek 3 miles above its mouth, No. 40.

	Ft.	in.
Shale.		
Coal	2	
Shale	10	
Coal	1	2
Coal (shaly)		3
Coal	1	3
Coal (shaly)	1	8
Coal	1	
Total lower bench	5	4

There are really two beds here, separated by 10 feet of shale, and it is possible that the lower represents the bed described under the last head, the situation being similar to that on South Fork of Pound River between Glady School and Donkey, as described on page 27.

On the east side of Indian Creek about half a mile due east of the Blair opening, at location No. 41, the bed is 30 inches thick and consists of solid coal. On McFall Fork, at location No. 42, the bed is much parted, as shown below.

Section of Blair coal on McFall Fork, No. 42.

	Ft.	in.
Shale (black at bottom).		
Coal		6
Parting		½
Coal		2½
Clay		5½
Coal		11
Bone		2
Coal		3
Clay (2 feet).		
	2	7¼

On Mullins Fork 2½ miles above its mouth, at No. 43, the bed has been opened and consists of 2 feet 2 inches of clean coal. On the head of Dotson Fork of Bowlecamp Creek (No. 44) the bed is about 2 feet thick. On the new Wise-Clintwood road (No. 45) the following section was measured:

Section of Blair coal on the Wise-Clintwood road, No. 45.

	Ft.	in.
Shale.		
Coal	1	2
Clay	1	6
Coal		7
	3	3

On the head of Dotson Fork of Birchfield Creek, at Nos. 46 and 47, the Blair bed is much the same as at the Blair opening described on page 29.

Section of Blair coal on the head of Dotson Fork, No. 46.

	Ft.	in.
Shale.		
Coal (soft)	2	
Clay		7
Coal (hard)	1	11
Bone		2
Coal (hard)		8
Shale.		
	5	4

On Guests River just north of Lipps, at location No. 48, the bed is 2 feet or more thick and made up of clean coal. (See section, p. 28.)

Clintwood coal.—The Clintwood is a thick bed throughout the region bounded roughly by Pound River and Birchfield and Indian creeks. It extends eastward to Clintwood, 2 miles east of this quadrangle, from which it takes its name. It persists as a thinner and parted bed throughout the rest of the quadrangle where the rocks at its stratigraphic horizon have not been eroded. It is thickest on Georges and Lick forks, where it is made up of two or more benches of coal separated by clay partings, some of which in places are 1 foot or more thick. In other parts of the quadrangle it seems split into two distinct beds separated by a considerable thickness of shale and sandstone. Everywhere it holds a nearly uniform distance of 200 feet above the Gladeville sandstone, and over a large part of its area it is overlain by a hard siliceous sandstone by which its outcrops may be recognized.

The bed has been extensively prospected by the Clinchfield Coal Corporation throughout the area of its best development. A few sections, out of many, are given below to show its thickness and make-up. On the head of Lick Fork, at No. 49, the bed is 15 feet thick, as shown below.

Section of Clintwood coal bed on head of Lick Fork, No. 49.

Shale.	Ft.	in.
Coal and bone		3
Coal	1	2
Clay (average)	1	3½
Coal	3	1½
Clay		1½
Coal		3½
Bone		2½
Coal	6	10¾
Shale		9½
Coal	1	3½
	15	5¼

This appears to be about the maximum thickness of the bed. In the region about the head of Georges Fork, on the south side, (No. 50), and on the north side, (No. 51), the bed is very thick, as shown by the sections below.

Section of the Clintwood coal on the head of Georges Fork, south side, No. 50.

Shale.	Ft.	in.
Clay		8
Coal (dirty)		3
Clay		3
Coal	3	
Bone		½
Coal	3	5
Clay.		
Total coal bed	6	11½

Section of Clintwood coal on head of Georges Fork, north side, No. 51.

Shale.	Ft.	in.
Coal	1	9
Clay	3	6
Coal	2	3
Clay	1	7
Coal	3	4
	12	5

The clay partings at this point are a serious detriment to the value of the bed.

On the head of Camp Creek three-fourths of a mile west of the quadrangle (No. 52), the section is similar to that at No. 51, but the bottom bench is thicker.

Section of Clintwood coal at the head of Camp Creek, No. 52.

	Ft.	in.
Shale.		
Coal		10
Clay	1	
Coal	2	1
Clay	2	
Coal	5	
	10	11

On a small stream just east of Camp Creek, at location No. 53, the bed is made up as follows:

Section of Clintwood coal east of Camp Creek, No. 53.

	Ft.	in.
Sandstone.		
Coal		10
Clay		10
Coal	1	8
Clay		½
Coal		4
Clay		½
Coal	1	5
Clay.		
	5	2

On Pound River 1¼ miles south of Phipps (No. 54) the bed is much deteriorated, as shown in the following section:

Section of Clintwood bed one and one-quarter miles south of Phipps, No. 54.

	Ft.	in.
Shale.		
Coal	1	4
Clay	3	2
Coal		9
Clay		1
Coal		9
Clay.		
	6	1

On McFall Fork 3 miles east of Pound (No. 55) the bed is in excellent condition.

Section on McFall Fork 3 miles east of Pound, No. 55.

	Ft.	in.
Sandstone (50 feet).		
Coal	4	3½
Bone		3
Clay		3
Coal	2	2
Clay.		
	6	11½

At this point the overlying hard siliceous sandstone is immediately in contact with the coal bed.

North of Birchfield Creek, 1½ to 2 miles west of the quadrangle, at Nos. 56 and 57, the bed is also in good condition and immediately overlain by sandstone.

Section of Clintwood coal north of Birchfield Creek, one and one-half miles west of quadrangle, No. 56.

	Ft.	in.	Ft.	in.
Sandstone (40 feet).				
Coal		8½		
Clay		½	3	11½
Coal	3	2½		
Clay		½		
Coal		2		
Bone		4		
Clay	1	6		
Coal	1			
Clay		5		
Coal		2		
Bone		1½		
Coal		1½		
Bone		1½		
Coal		8		
Clay (5 feet).				
	8	7½		

The bed at this point carries 4 feet of workable coal at the top, the rest of it being practically worthless.

At location No. 57, 1½ miles southwest of No. 56, the bed is 3 feet 10 inches thick and has a clay roof and floor.

The Clintwood bed shows its presence at a number of points in the southeast corner of the quadrangle south of Birchfield Creek and on the headwaters of that stream, but no good exposures were found from which its thickness and make-up could be determined. It rises to the top of the ridges and knobs in the southeast corner.

On the head of Indian Creek it is mined at the Roberts bank (No. 58). On the west side of Indian Creek 3 miles above its mouth (No. 59) the bed lies close beneath its heavy sandstone and is much parted and about worthless.

Section of Clintwood coal on Indian Creek 3 miles above its mouth, No. 59.

	Ft.	in.
Sandstone.		
Coal	2±	
Clay	1	9
Coal		6
Clay		1
Coal		3
Clay		5
Coal		3
Clay		6½
Coal		6
Clay (?).		
	6	3½

About 30 feet below the bed shown in the above section, is another bed 1 foot or more thick that may be a split from the Clintwood.

In all the region west of Indian Creek and along Pound River southwest of Pound the bed is generally a little over 3 feet thick, including partings, and commonly has a 2-foot bench of solid coal. Just west of Donkey, at No. 60, the Clintwood shows the following section:

Section of Clintwood coal just west of Donkey, No. 60.

	Ft.	in.
Sandstone.		
Coal	1	11
Clay		10
Coal		10
	3	7

At this point the bed is in the bottom of the Pound syncline, here a narrow trough, whose southeast limb dips 30° NW.

At Dewey (No. 61) the bed is 29 inches thick, as follows:

Section of Clintwood coal at Dewey, No. 61.

	Ft.	in.
Sandstone.		
Coal		2
Bone		3
Coal		9
Shale		2
Coal		11
	2	3

On the North Fork of Pound River three-fourths of a mile northeast of Flat Gap post office, at No. 62, the Clintwood bed has been opened and is reported 18 inches to 2 feet thick, but it could not be seen. Near the west margin of the quadrangle half a mile south of Cumberland River, in Kentucky, at No. 63, the Clintwood bed has been opened and shows the following section:

Section of Clintwood coal near the west margin of the quadrangle half a mile south of Cumberland River, No. 63.

	Ft.	in.
Shale.		
Coal	2	
Clay		2
Coal		3
Clay		1
Coal		7
Clay (amount seen, 1 foot).		
	3	1

At No. 64, half a mile east of No. 63, another opening revealed the following section:

Section of Clintwood coal half a mile south of Cumberland River, near the west boundary of the quadrangle, No. 64.

	Ft.	in.
Sandstone.		
Shale (6 inches).		
Coal	2	
Clay		2
Coal		2½
Clay	5	
Coal	1	7
	8	11½

On Guests River three-fourths of a mile north of Lipps post office, at No. 65, the Clintwood bed seems to be represented by two beds 20 feet apart and under heavy siliceous sandstone, as shown in the following section:

Section showing the Clintwood coals on Guest River near Lipps. No. 65.

	Ft.	in.
Sandstone	30	
Coal, upper bench (?)	2	
Shale and sandstone	20	
Coal } lower bench (?)	1	
Clay } lower bench (?)		1
Coal } lower bench (?)	1	2
Clay (3 feet).		
	54	3

The Clintwood bed has been opened at several points on the East Branch of Guests River but is apparently thin and of little value.

The general chemical composition of the Clintwood coal was not well determined because there was no opportunity to collect unweathered samples for analysis within the quadrangle. Samples were collected from working banks at Clintwood and farther south and the analyses are published in the table (p. 54), Nos. 14766 and 14767. These show a very clean and pure coal.

Coal bed at top of sandstone above Clintwood coal.—Locally a workable coal bed occurs at the top of the sandstone above the Clintwood coal. Probably it is a persistent but generally thin bed, for ordinarily only shale is seen for 200 feet above the sandstone. The best development of this bed observed is on Mullins Fork at No. 66.

Section of coal bed on the west side of Mullins Fork, No. 66.

	Ft.	in.
Coal		6+
Clay	1	
Coal	2	
	3	6

This bed shows on the hill tops near Hurricane post office on the new Wise-Clintwood road, but no good section of it was obtained. It is also exposed on the road west of Flat Gap post office near the west side of the quadrangle (No. 67), where it is 2 feet thick.

Thin coal.—On the head of the North Fork of Pound River about a mile southwest of Flat Gap post office (No. 68) a coal about 150 feet above the Clintwood and 1 foot thick has been dug on a small scale.

Bolling ("Five-foot") coals.—The names Upper and Lower Bolling are here applied to a pair of beds 20 to 40 feet apart, the upper one of which is known otherwise as the "Five-foot" coal. The Lower Bolling is 250 to 300 feet above the Clintwood bed. The name is adopted because one or both beds are worked by members of the Bolling family at several points in the southwestern part of the quadrangle. The beds underlie an unbroken area of about 25 square miles in the quadrangle west of Guests River and south of North Fork of Pound River. They also underlie an extensive area in the Buck Knob region and a number of smaller areas on the high knobs east of Indian Creek and south of Georges Creek. In these areas east and northeast of Indian Creek the beds are in their best condition.

On the summit at the head of Mill Creek northeast of Pound (No. 69) the Lower Bolling coal has the following section:

Section of Lower Bolling coal on the summit at the head of Mill Creek northeast of Pound, No. 69.

	Ft.	in.
Shale.		
Coal	3	
Clay		3
Coal	1	
	4	3

About 3 miles northeast of Pound (No. 70) the Upper Bolling bed is as follows:

Section of Upper Bolling coal 3 miles northeast of Pound, No. 70.

	Ft.	in.
Sandstone.		
Shale (4 feet).		
Coal	2	
Bone		3
Coal	2	1
Clay		1
Coal		1
	4	6

The two coal beds are 20 feet apart at this point.

Near the summit at the head of Georges Fork (No. 71) prospects on both beds were open to inspection. The interval is 40 feet.

Section of Bolling coals at summit at head of Georges Fork, No. 71.

	Ft.	in.
Upper bed.		
Shale.		
Coal, clean	3	10
Clay.		
Interval, 40 feet.		
Lower bed.		
Shale.		
Coal, clean	2	2

North of the head of McFall Fork (No. 72) the following sections were obtained.

Section of Bolling coals north of the head of McFall Fork, No. 72.

Upper bed.

	Ft.	in.
Shale (5 feet).		
Coal, clean		4
Clay.		
Interval, 40 feet.		

Lower bed.

Shale (4 feet).		
Coal	3	4
Bone		3
Clay.		
	3	7

The Bolling coals are present and one and perhaps both are of good thickness on the high hill between Bowlecamp and Birchfield creeks. One of the two was measured at prospect pits on the south side, but the field notes do not designate which bed.

Section of one of the Bolling coals on south side of hill between Bowlecamp and Birchfield creeks, Nos. 73 and 74.

No. 73.

	Ft.	in.
Coal	2	9
Clay.		

No. 74.

Coal	5	4

These coals are present on the high hills between the heads of Indian and Birchfield creeks, probably on other knobs in the southeast corner of the quadrangle, and on the high knob between the two branches of Guests River southeast of Pinnacle Gap.

Between Indian Creek and Guests River in the Buck Knob region one or both of the coals is of good thickness except on the long spur north of Buck Knob. Between Indian and Glady creeks (No. 75) the beds are as shown below.

Section of Bolling coals between Indian and Glady Creeks, No. 75.

Upper bed.

	Ft.	in.
Shale.		
Coal		3½
Shale	1	6½
Coal		½
Shale		5
Coal	3	4½
Interval, 18 feet.		
	5	8

Lower bed.

	Ft.	in.
Shale.		
Coal	3	
Clay (5 inches).		

The upper bed shows shale and coal in the upper part, a feature that is common in the bed farther west.

On the spur north of Buck Knob, at location No. 76, a number of pits on both beds show only 1 to 2 feet of coal. This condition is shown in the following sections, which may be regarded as typical for the locality.

Sections of Bolling coals on spur north of Buck Knob, No. 76.

	Ft.	in.
Coal (upper bed)	1±	
Interval, 18 feet.		
Coal (lower bed)	1	5
Clay.		

A slight improvement is shown 1 mile northwest of the last locality and 1 mile southeast of Dewey:

Section of Bolling coals on point of spur 1 mile southeast of Dewey, No. 77.

	Ft.	in.
Sandstone.		
Coal, upper bed	1	9
Interval, 23 feet.		
Coal, lower bed	1	6±

South of Buck Knob the Upper Bolling bed takes on a somewhat rashy and laminated character in its upper part, as shown by the following sections:

Section of Upper Bolling coal one and one-half miles southeast of Buck Knob, No. 78.

	Ft.	in.
Coal, laminated thin partings of rash or mother of coal	1	6
Coal, laminated	1	
Clay		2
Coal		3½
Clay and bone		1
Coal		1¼
Clay and bone		1½
Coal		2
Clay (2 feet).		
	3	5¼

Section of Upper Bolling coal 2 miles southeast of Buck Knob, No. 79.

	Ft.	in.
Shale.		
Coal, laminated	1	3
Coal, soft shaly		3
Coal, hard; bright	2	
Clay.		
	3	6

At 70 feet below the Upper Bolling at this point is a bed, reported to be 18 inches thick, which is probably the Lower Bolling with an enlarged interval between it and the Upper Bolling.

On Guests River 2 miles north of Lipps (No. 80) the following section was obtained:

Section of Upper Bolling bed on Guests River 2 miles north of Lipps, No. 80.

	Ft.	in.
Shale coal, bone (2 feet).		
Coal		4
Clay		½
Coal		1½
Clay		1½
Bone		1½
Coal	2	2¾
Bone		1
Coal	2	11
Clay.		
	5	11¾

At river level at the mouth of Critical Fork (No. 81) a bed, apparently the Lower Bolling, is opened under a heavy sandstone.

Section of the Lower (?) Bolling coal on Guests River at mouth of Critical Fork, No. 81.

	Ft.	in.
Sandstone.		
Bone, rash, and pyrite		8
Coal, many thin partings and lenses of pyrite	3	6
Clay.		

On Steve Horn Branch at the west base of Buck Knob the beds have the following section:

Section of Bolling coals at the west base of Buck Knob, No. 82.

Upper bed.

	Ft.	in.
Shale.		
Coal		3
Shale	2	
Coal	1	10½
Bone		½
Coal	1	5
Shale.		
	5	7

Interval (shale?), 20 feet.

Lower bed.

	Ft.	in.
Coal	1	2
Clay		2½
Coal		9
Clay		1
Coal		2
	2	4½

On the upper courses of both North and South forks of Pound River the Bolling coals are of fair thickness and quality, the upper being about 4 feet and the lower 2½ feet thick.

At the place of J. E. Bolling, 1½ miles west of Dewey (No. 83), both beds are opened and have the following section:

Upper bed.

	Ft.	in.
Shale.		
Coal	2	
Bony coal		2
Coal	1	9
	3	11

Interval, 20 feet.

Lower bed.

	Ft.	in.
Coal	2	6
Shale.		

At Reuben Bolling's place, over 2 miles southwest of Dewey (No. 84), the Upper Bolling bed is worked and is made up as follows:

Section of Upper Bolling coal at Reuben Bolling's, 2 miles southwest of Dewey, No. 84.

[Analysis of sample from this bank is given in the table on p. 54, No. 15174.]

	Ft.	in.
Shale (8 feet).		
Coal, thin shale parting		4
Clay		10
Coal[1]	1	5½
Clay		1
Coal[1]	1	5
	4	1½

[1]Included in sample.

About a mile southwest of Flat Gap post office, on the land of W. A. Bolling (No. 85), both beds have been opened.

Section of Bolling coals at W. A. Bolling's, about 1 mile southwest of Flat Gap post office, No. 85.

Upper bed.	Ft.	in.
Shale.		
Coal and bone		4
Clay		6
Coal	1	6
Clay		½
Coal	1	7½
	4	
Shale (15 feet).		
Lower bed.		
Coal, reported 3 feet, exposed	2	

On the west side of the quadrangle 1 mile south of Cumberland River (No. 86) both beds have been opened, but only the lower bed was accessible.

Section of the Bolling coals on the J. H. Mullen estate on the west side of the quadrangle 1 mile south of Cumberland River, No. 86.

Upper bed.	Ft.	in.
Coal, reported 3 feet or more; exposed	2	
Interval, 30 feet.		
Lower bed.		
Coal[1]	2	3
Clay		2
Coal[1]	1	6
Clay		4
Coal[1]		4
Total Lower Bolling	4	7

[1]Included in sample for analysis No. 15173, p. 54.

On Powell River on the south margin of the quadrangle (No. 87), a bed believed to be one of the Bolling coals has been opened and shows the following section:

Section of one of the Bolling coals on Powell River near margin of the quadrangle, No. 87.

	Ft.	in.
Shale.		
Coal		8
Clay		1
Coal	1	8
	2	5

On account of their extent and comparative uniformity as workable beds throughout the area, the Bolling coals must rank among the most valuable coal beds of the Virginia part of the Pound quadrangle.

Standiford coals.—The Bolling coals are overlain by 260 feet of barren shale and sandstone. On the South Fork of Pound River a thin coal bed 80 feet above the Bolling coal was seen at two points, but east of Indian Creek a fully exposed section extending 150 feet above the Bolling coals is without coal, and no bed of value is known anywhere in the interval.

At the top of this barren group of shales and sandstones are two coal beds which are named the Standiford coals from a man of that name, who has worked both beds on the South Fork of Pound River. They are 20 feet apart at the type locality and constitute a pair in all respects similar to the Bolling coals. The Standiford coals are present only in the Buck Knob and Black Mountain regions west of Guests River, and their areal extent is therefore much less than that of the Bolling coals.

On the David Sturgill place, at the head of the South Fork of Cumberland River (No. 88), the Lower Standiford bed is worked. At this bank the bed has a shale roof and clay floor and comprises 3 feet 2 inches of clean coal. Its composition is shown in anaylsis No. 15172 of the table (p. 54). A few rods east of the Sturgill bank is an opening into the Upper Standiford bed (No. 89), in which the coal is 2 feet 6 inches thick and has a sandstone roof and clay floor. The beds here are about 20 feet apart.

At the Standiford place on the South Fork of Pound River (No. 90), the upper bed is opened on the east side and the lower on the west side of the valley. The lower bed at this point is clean coal 31 inches thick and has the section shown below:

Section of Upper Standiford coal at the Standiford place on South Fork of Pound River, No. 90.

	Ft.	in.
Shale (6 feet).		
Coal	2	2
Parting		½
Coal		11½
Clay.		
	3	2

A bed cut on the new road north of Fox Gap, at an elevation of 2,235 feet above the sea (No. 91), is regarded as the Upper Standiford. The section is given below.

Section of Upper Standiford coal on new road north of Fox Gap, No. 91.

	Ft.	in.
Shale.		
Coal	1	
Clay		1½
Coal	1	
Clay	3	
Shale, purple (3 feet).		
Total coal bed	2	1½

The lower bed is not exposed, though it may be present under cover. The purple shale is significant, for it occurs below a coal at about the same level on the south side of Fox Gap and serves to identify the bed with the Upper Standiford.

On the new road south of Fox Gap, at the foot of the hill (No. 92), the Upper Standiford is cut and is of good thickness.

Section of Upper Standiford coal in new road south of Fox Gap, No. 92.

	Ft.	in.
Shale.		
Coal	2	4
Clay		2
Coal	1	4
	3	10

This bed is also opened on the old road less than a quarter of a mile northeast of No. 92 and at that point has the purple shale beneath it as it has at Station No. 91, just described.

The rocks rise southeastward down Guests River and carry the outcrop of the coal beds upward into the hillsides, a fact which makes it probable that the Standiford coals are among those prospected by the Clinchfield Coal Corporation between the Low Splint (Buck Knob) and Bolling coals on the north and south sides of Buck Knob.

On Critical Fork of Guests River, at No. 93, two beds are exposed that are regarded as the Standiford coals, although on account of a rather strong westward dip the distance between them seems greater than known elsewhere.

Section of Standiford coals on Critical Fork of Guests River, No. 93.

Upper bed.

	Ft.	in.
Shale.		
Bone		3
Coal		2
Parting, clay, bone, and dirty coal		2
Coal, clean	3	5
Clay		2
Coal		3
	4	5
Clay.		
Interval, 40± feet.		

Lower bed.

	Ft.	in.
Shale roof.		
Coal (seen)	2	

Near the head of Powell River (No. 94) a bed regarded as one of the Standiford coals is exposed in the stream:

Section of one of Standiford coal beds on branch near head of Powell River, No. 94.

	Ft.	in.
Coal		1
Clay		½
Coal	1	9½
	1	11

It appears from the foregoing account that the Standiford coals are of workable thickness throughout the Black Mountain and Buck Knob regions. They should also be present in Bowlecamp Knob near its summit.

Taggart coal.—About 80 feet above the Standiford coals is a bed known in the region as the Taggart bed, which appears to be the same as the Keokee bed of Kentucky reports. It has been extensively prospected by the Virginia Coal and Iron Company on the head of Roaring Fork of Powell River, where it is 4 feet or more thick and varies from a solid bed to a bed with a shale parting as much as 6 feet thick. A bed, supposedly the Taggart, at one point on the South Fork of Pound River (No. 95) has the following section:

Section of the Taggart coal bed on South Fork of Pound River, No. 95.

	Ft.	in.
Shale.		
Coal, clean	2	10
Shale	6	
Coal, clean	2	6
Clay.		
	11	4

On the hill south of Critical Fork of Guests River (No. 96) the section is as follows:

Section of Taggart coal bed on the hill south of Critical Fork, No. 96.

	Ft.	in.
Shale.		
Bone		3
Coal		11
Clay		2
Coal		10½
Clay.		
	2	2½

On Powell River, at Nos. 97 and 98, the bed is in excellent condition, as shown by the following sections:

Section of Taggart coal on Powell River, No. 97.

	Ft.	in.
Earth.		
Coal	2	10
Bone		1½
Coal	1	5
	4	4½

At Station No. 98, about half a mile south of No. 97, the following section is exposed:

Section of Taggart coal on Powell River, No. 98.

	Ft.	in.
Coal	3	7
Shale	10	
Sandstone	10	
Coal	3	
Sandstone	40	
Coal	3	6
Shale and unexposed	10	
Coal	1	

A few feet away the upper bed of the section at No. 98 is 4 feet 5 inches thick and all coal. Probably the upper bed would best be regarded as the Taggart and the lower ones as beds not present in other sections or present and not exposed.

On Roaring Fork of Powell River the following sections furnished by the Virginia Coal and Iron Company have been selected from many as being typical:

Section of Taggart coal on Roaring Fork of Powell River, Nos. 99 and 100.

No. 99.

	Ft.	in.
Shale.		
Coal	2	11
Shale	3	10
Coal	2	
Shale		8
Coal		4
Clay.		
	9	9

No. 100.

	Ft.	in.
Shale.		
Coal	4	2
Clay.		

The section at No. 99 is similar to the section of the same bed in South Fork of Pound River, No. 95.

On Whitley Fork in the southwest corner of the quadrangle (No. 101) the bed is 37 inches thick.

Low Splint coal.—The name Low Splint is applied by the Virginia Coal and Iron Company and in reports of the Kentucky Geological Survey to a coal bed 220 feet or so above the Taggart bed.

The Low Splint bed is opened at the George Phillips place on South Fork of Pound River (No. 102), where it shows the following section:

Section of Low Splint coal on George Phillips place on South Fork of Pound River, No. 102.

	Ft.	in.
Shale.		
Coal	2	1
Clay		1½
Coal		6½
Clay.		
	2	9

In a ravine a short distance east of the new road north of Fox Gap (No. 103) a bed is opened that is identified as the Low Splint.

Section of Low Splint bed east of new road north of Fox Gap, No. 103.

	Ft.	in.
Shale.		
Coal		8
Bone		½
Coal	2	4½
Clay		2
Coal, slaty		3
Coal		9
Clay		3
Coal	1	2
Clay.		
	5	8

It is probable that a coal prospected on Buck Knob by the Clinchfield Coal Corporation and called by it the Buck Knob is the Low Splint.

On the head of Critical Fork (No. 104) a bed showing a top bench of 23 inches of coal with a reported thin parting and lower bench seems likely to be the Low Splint.

The Low Splint at an opening south of Powell River (No. 105) shows the following section:

Section of Low Splint coal south of Powell River, No. 105.

	Ft.	in.
Shale.		
Coal		1
Bone		1
Coal	3	4

This bed has been thoroughly prospected on Roaring Fork by the Virginia Coal and Iron Company and a few representative sections are given below, Nos. 106 to 109.

Sections of Low Splint bed on Roaring Fork.

West side, No. 106.

	Ft.	in.
Shale.		
Coal	1	7
Shale		3
Coal	1	1
Shale		3
Coal		4
	3	6

Head of river, No. 107.

	Ft.	in.
Shale.		
Coal	2	9
Shale.		

East side of river, No. 108.

	Ft.	in.
Shale.		
Coal	1	10
Shale		7
Coal	1	
Shale		10
Coal		9
	5	

East side of river, No. 109.

	Ft.	in.
Shale.		
Coal	3	9
Shale.		

Phillips coal.—At the head of South Fork of Pound River, near the house of Ambrose Phillips, a coal bed, 260 feet above the Low Splint bed and provisionally named the Phillips bed, has been opened. At the Phillips place (No. 110) it is reported to be a clean splint coal 2 feet 2 inches thick. On the head of Critical Fork of Guests River (No. 111) a bed that has been opened and is reported 4 feet thick and nearby is not fully exposed but at least 2 feet thick, appears to be at the horizon of the Phillips coal. It was not seen elsewhere. The Phillips coal may be the same as the Dean coal of the Kentucky Geological Survey reports.

Coal 80 feet above the Phillips coal.—At the Phillips place (No. 112) occurs an 18-inch bed, 80 feet above the Phillips coal, not observed elsewhere.

Coal 215 feet above the Phillips coal.—At the head of South Fork of Pound River (No. 113) a bed is exposed which is 215 feet above the Phillips bed and which is made up as follows:

Section of coal bed 215 feet above the Phillips bed on the head of South Fork of Pound River, No. 113.

	Ft.	in.
Shale.		
Coal	1	4
Shale		6
Coal		6
Clay		2
Coal	1	7
Clay.		
	4	1

A bed regarded as the same as that at No. 113 is exposed on the head of Critical Fork (No. 114) and shows the following section:

Section of coal bed at head of Critical Fork, No. 114.

	Ft.	in.
Sandstone.		
Coal	1	2
Clay		2
Coal, hard	2	
	3	4

Pardee (Limestone or Parsons) coal.—The Pardee coal bed takes its name from the Pardee mine, just off the southwest corner of the quadrangle. It is called the Limestone bed in reports of the Kentucky Geological Survey because of the occurrence of a persistent limestone 50 to 100 feet above it to the west of this quadrangle, in Kentucky. It is also called the Parsons bed by the Virginia Coal and Iron Company.

The Pardee bed is 385 feet above the Low Splint bed. It is 7 to 10 feet thick where unbroken by partings, but it varies greatly within short distances owing to the occurrence of partings of clay or shale which in places reach a thickness of several feet. It underlies only a small area near the top of Black Mountain. It is mined at the Pardee mine and has been very thoroughly prospected around the head of Roaring Fork by the Virginia Coal and Iron Company. A measurement of the bed obtained on South Fork of Pound River (No. 115) is as follows:

Section of Pardee coal on South Fork of Pound River, No. 115.

	Ft.	in.
Coal	1	6
Clay		3½
Coal	1	7
Clay		½
Coal		7
Clay		3
Coal		½
Clay		½
Coal		4
Clay		1
Coal	1	1½
Clay		2
Coal		11
	6	11½

The following sections around the head of Roaring Fork have been selected from those furnished by the Virginia Coal and Iron Company.

Sections of Pardee coal around the head of Roaring Fork.

No. 116, between Roaring Fork and Powell River.

	Ft.	in.
Shale.		
Coal	2	
Shale	12	
Coal	1	2
Shale	20	
Coal	1	2

No. 117, head of Osborne Fork.

	Ft.	in.
Shale.		
Coal	4	1
Shale	1	7
Coal	4	2
Shale.		
	9	10

No. 118, head of Straight Fork.

	Ft.	in.
Shale.		
Coal	6	6
Shale.		

No. 119, west side of Straight Fork.

	Ft.	in.
Shale.		
Coal	4	6
Shale		7
Coal	2	7
Shale		½
Coal	1	6
Shale		5
Coal	1	9
	11	4½

No. 119½, ridge between Whitley and Roaring forks.

	Ft.	in.
Shale.		
Coal		6
Shale		5½
Coal	3	11½
Shale		2
Coal	1	6
Shale	3	7
Coal	3	6
Shale		1
Coal		2
Shale		5
Coal		1½
Slate		1
Coal	1	7
Shale.		
	16	1½

The Pardee coal is rather hard and of the composition common to the Virginia and eastern Kentucky coals, as shown by the analysis, No. 15099 of the table on p. 54.

High Splint coal.—Practically 400 feet above the Pardee bed is the High Splint bed, well known to the west of this region in Kentucky. It is a genuine splint coal 4 to 5 feet thick underlying a small area near the top of Black Mountain. On the north side of Black Mountain at the head of South Fork of Pound River (No. 120) the following section was obtained:

Section of High Splint coal at the head of South Fork of Pound River, No. 120.

	Ft.	in.
Sandstone.		
Coal	3	4
Bone		1
Coal	1	
	4	5

The following sections (Nos. 121 to 123) are taken from those furnished by the Virginia Coal and Iron Company, obtained by extensive prospecting around the head of Roaring Fork of Powell River. The three sections given under No. 122 were taken within a distance of 1,000 feet and show exceptional variation.

Sections of the High Splint coal around the head of Roaring Fork of Powell River.

No. 121, on point of ridge between Powell and Roaring forks.

	Ft.	in.
Shale.		
Coal	2	4
Shale		2
Coal		6
	3	

No. 122, head of Osborne Fork.

	Ft.	in.
Shale.		
Coal	1	2
Shale	1	2
Coal		2
Shale		9½
Coal	1	10
Shale.		
	5	1½

	Ft.	in.
Shale.		
Coal	1	10
Shale	4	9
Coal	1	2
Shale.		
	7	9

	Ft.	in.
Shale.		
Coal	4	5
Shale.		

No. 123, ridge between Straight Fork and Cumberland River.

	Ft.	in.
Shale.		
Coal	4	5
Shale.		

This bed appears to be of excellent quality and is said to burn very freely. No samples of unweathered coal could be had for analysis. Except for the local irregularity shown by the three sections of No. 122 the bed is very uniform in thickness and make-up, maintaining a general thickness of 4 to 4½ feet all around the head of Roaring Fork. At only one point does it fall as low as 3 feet 4 inches except at the extreme southeast, where it thins and is much parted, as shown by section 121.

Coals above the High Splint bed.—On Black Mountain at two points. at least, coal was seen above the High Splint bed, but the beds were not exposed and no information was obtained about their thickness or character.

CHEMICAL COMPOSITION OF THE COALS.

In the subjoined table of analyses is shown the chemical composition of some of the coal beds of the region. But a small number of samples was taken because, owing to the scarcity of deep mines, there are very few opportunities for obtaining fresh unweathered coal. Most of the samples from local mines are probably somewhat affected by weathering. However, the composition of such samples approximates that of fresh coal closely enough for rough comparisons.

The samples were collected as follows: From the fresh face of the bed, or a face as nearly fresh as could be had, a uniform cut was made from top to bottom of sufficient size to yield 5 pounds to the foot after rejecting all partings that would not be included in the coal as marketed. This coal was pulverized and quartered down in the mine until sufficient coal of a size that would pass through a ½-inch mesh remained to fill a 2-quart galvanized can. This was sealed with adhesive tape and mailed to the laboratory for analysis.

The coals of this quadrangle are all bituminous and in composition are comparable to the coals of the east side of the Appalachian field from Russell County, Virginia, to Alabama, exclusive of Lookout Mountain. Samples from Russell, Dickenson, Wise, and Lee counties, Virginia, and those of eastern Kentucky run close together in average composition. All the samples from the Pound quadrangle are low in sulphur and moisture, and all but those from the Pardee and Bolling beds are notably low in ash. A large number of locality samples is, however, needed to give more satisfactory data. It should be added that the calorific determinations, based on samples from country banks or, in some cases, probably on weathered samples, are to be regarded as not showing the full heat value of the fuels.

The coals of this quadrangle all differ from the coals of the Pocahontas region in respect to content of volatile hydrocarbons and fixed carbon. The Pocahontas coals, generally having less than 20 per cent volatile and more than 70 per cent fixed carbon, are classed with the semibituminous coals like those of the Clearfield district of Pennsylvania. On the other hand, the coals described in the preceding pages contain over 30 per cent of volatile matter. The high volatile content of the coals of the Pound quadrangle invites consideration of by-product processes in coking.

The coals of this region are suitable for any of the uses to which the coals south of the Pocahontas region (except the semibituminous coal of Lookout Mountain in Georgia and Alabama) are put—for domestic use, including the grate, for the generation of steam, for coke and gas—and they will probably compare favorably with most of the coal mined for such uses in the southern Appalachian field.

Their coking qualities are mostly unknown. The Imboden bed at Stonega, southwest of the Pound quadrangle, is regarded as one of the best coking coals of the country. This bed is supposed to be the same as the Edwards bed in the Norton formation. The Glamorgan coal mined at Glamorgan makes good coke, into which the output of the mine is largely converted. It is quite probable that some of the other Norton coals also possess good coking qualities.

Analyses of coal samples from the Pound and Clintwood quadrangles.

[Collected in Virginia and in Kentucky just west of Virginia. Made by the U. S. Bureau of Mines. A. C. Fieldner, chemist in charge.]

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Heating value. Calories.	Heating value. British thermal units.	Name of mine and location.	Collector.	Coal bed.
14766	1.2	A	2.2	34.2	60.4	3.2	.85					8,110	14,590	Mine of John A. Yeates, 1 mile southwest of Clintwood.	W. A. Nelson	Clintwood.
		B	1.0	34.6	61.2	3.2	.86					8,205	14,770			
		C		34.9	61.8	3.3	.87					8,290	14,920			
		D		36.1	63.9		.96					8,570	15,420			
14767	3.8	A	4.3	29.4	62.1	4.2	1.02							Mine of Elbert Powers, 3 miles southeast of Clintwood.	do	do
		B	1.0	30.4	64.2	4.4	1.05									
		C		30.7	64.9	4.4	1.07									
		D		32.1	67.9		1.12									
15099	1.0	A	2.3	33.8	54.7	9.21	1.56	4.99	74.46	1.57	8.21	7,420	13,360	Pardee No. 1 mine of Blackwood Coal & Coke Co., Pardee.	Chas. Butts	Pardee.
		B	1.8	34.2	55.2	9.30	1.58	4.93	75.21	1.59	7.39	7,495	13,490			
		C		34.6	56.0	9.43	1.60	4.85	76.20	1.61	6.31	7,595	13,670			
		D		38.2	61.8		1.77	5.35	84.13	1.78	6.97	8,385	15,100			
15100	1.6	A	2.6	38.1	59.3	5.0	1.37					7,895	14,220	Glamorgan No. 3 mine of Stone Gap Colliery Co., Glamorgan.	do	Glamorgan.
		B	1.1	33.6	60.2	5.1	1.39					8,025	14,450			
		C		34.0	60.9	5.1	1.41					8,115	14,600			
		D		35.8	64.2		1.49					8,550	15,390			
15101	2.0	A	3.2	31.8	59.1	6.37	.87	5.27	78.02	1.65	7.82	7,730	13,910	Do.	do	do
		B	1.3	31.9	60.8	6.50	.89	5.15	79.61	1.68	6.17	7,885	14,200			
		C		32.3	61.1	6.58	.90	5.08	80.65	1.71	5.08	7,990	14,380			
		D		34.6	65.4		.96	5.44	86.33	1.83	5.44	8,550	15,390			
15172	2.8	A	4.1	35.2	55.7	5.0	1.74					7,725	13,910	Mine of David Sturgill, located in Ky., 1½ miles south of Flat Gap, Va.	do	Lower Standiford.
		B	1.3	36.2	57.3	5.2	1.79					7,950	14,310			
		C		36.7	58.1	5.2	1.81					8,055	14,500			
		D		38.7	61.3		1.91					8,500	15,300			
15173	2.6	A	4.0	31.8	53.0	11.2	.97					7,140	12,850	Mine of J. H. Mullin, located in Ky., 3 miles southwest of Flat Gap, Va.	do	Lower Bolling.
		B	1.4	32.6	54.5	11.5	1.00					7,330	13,200			
		C		33.1	55.3	11.6	1.01					7,435	13,380			
		D		37.4	62.6		1.14					8,415	15,150			
15174	5.8	A	6.9	30.4	54.6	8.1	.95					7,210	12,980	Mine of Reuben Bolling, 2 miles east of Flat Gap.	do	Upper Bolling.
		B	1.2	32.3	57.9	8.6	1.01					7,655	13,780			
		C		32.6	58.6	8.8	1.02					7,745	13,940			
		D		35.8	64.2		1.12					8,485	15,280			

A. Analysis of sample as received.
B. Analysis of sample after drying at a temperature a little above the normal until its weight becomes constant.
C. Represents the theoretical composition of the coal after the moisture is eliminated.
D. Represents the coal after all moisture and ash have been theoretically removed.

MINING CONDITIONS.

The coal beds of the region are nearly flat or gently inclined. Level haulways are possible throughout the field, permitting the use of electric haulage. It seems likely that all the beds of the Wise formation can be reached by drift mines, but it will be necessary to shaft for the coals of the Norton and Lee formations. In general the beds have a good roof. Such mines as have been opened appear to be free from gas or water in troublesome quantities.

The country has an abundant supply of mine timber, and the water supply for steam and other purposes will probably always be ample. The construction of railroads for transportation will be the most expensive factor in mining enterprises. That subject has been discussed on page 4.

AMOUNT OF ULTIMATELY AVAILABLE COAL.

The amount of ultimately available coal has been computed with the results shown in the following table:

Amount of available coal in the Pound Quadrangle, Virginia.

Bed	Thickness	Area in square miles	Tonnage [1,152,000 tons per sq. mile for each foot in thickness of coal.]
High Splint	3′ — 10″	1.60	7,060,000
Pardee	7′ — 6″	4.80	41,470,000
1st coal below Pardee	2′ — 0″	6.57	15,130,000
2nd coal below Pardee	1′ — 0″	8.17	9,520,000
Phillips	2′ — 0″	9.62	22,160,000
Low Splint	3′ — 2″	13.92	50,830,000
Taggart	4′ — 0″	17.19	79,210,000
Upper Standiford	3′ — 0″	20.15	69,640,000
Lower Standiford	2′ — 6″	20.15	58,000,000
Upper Bolling	3′ — 4″	39.19	150,300,000
Lower Bolling	2′ — 4″	39.19	105,200,000
1st coal above Clintwood	2′ — 0″	75.92	174,900,000
Clintwood (thick)	7′ — 3″	17.91	149,580,000
Clintwood (thin)	3′ — 8″	58.00	245,200,000
Blair	2′ — 8″	91.29	279,750,000
Coal 70 ft. above Glamorgan	2′ — 6″	99.61	285,700,000
Glamorgan (thick)	2′ — 7″	59.80	179,100,000
Glamorgan (thin)	2′ — 0″	49.20	113,350,000
Total Wise			2,136,080,000
Norton	7′ — 2″	137.72	1,137,550,000
Lee	7′ — 4″	137.72	1,162,920,000
Grand total			4,436,550,000

In the above table the results are given to the nearest 10,000 tons.

The minimum thickness of a coal bed considered as ultimately minable in a commercial sense is 14 inches and the maximum depth for that thickness is taken at 1,700 feet. On this basis the comparatively meager data for the Norton and Lee formations in Virginia indicate a total thickness of 7 feet 2 inches in the former and 7 feet 4 inches in the latter. That is the amount of coal fulfilling the conditions of depth and thickness stated above equals a single bed 7 feet 2 inches thick in the Norton and 7 feet 4 inches in the Lee and having an areal extent equal to the mean area underlain by those formations.

The average thickness of the High Splint, Pardee, Low Splint, Taggart, Bolling, Clintwood (where 7 feet 3 inches thick), and Glamorgan (where 2 feet 7 inches) is based on an adequate number of detailed measurements and can be accepted as reliable. The thickness in the case of the other beds is less reliable.

Beds other than those estimated were seen at one or a very few points of which so little is known that they were left out in this computation and this fact together with the fact that the beds estimated are as likely to average somewhat thicker as they are to be thinner supports confidence in the belief that the total estimated tonnage, enormous though it be, does not exceed the actual amount of ultimately minable coal in the Pound Quadrangle.

DEVELOPMENTS.

The region is almost entirely undeveloped, only the Glamorgan mine being operated on a commercial scale. Here and there a local mine supplies the surrounding neighborhood. However, most of the best coal land is in the possession of large coal companies, the coal resources have been ascertained by thorough prospecting, and developments on a large scale may be expected in the near future.

SUMMARY.

It was ascertained by this survey that the maximum thickness of the coal-bearing rocks of the area is 4,800 feet. This thickness is attained in Black Mountain and is probably the maximum thickness for the coal measures of the Appalachian coal field outside of the Coosa and Cahaba coal fields of Alabama.

The coal resources of the lower 2,000 feet of these rocks could not be thoroughly investigated, but it is known from borings and scattered

exposures of coal beds on the outcrops of these rocks that there are a dozen beds or so, 14 inches to 4 feet thick, at depths of less than 2,000 feet, the coal in all of which is to be considered ultimately available. In the upper 2,800 feet of the coal rocks there are 16 coal beds from 18 inches to 10 feet thick, all but one of which is known to be 2½ feet or more thick over large areas. The areal extent of the individual beds varies from 2 or 3 square miles to 100 square miles or so, the extent depending on variation in thickness of the beds and their position in the hills. The total amount of ultimately available coal is computed to be 4,295,272,312 short tons. The coal of the region is all bituminous, has the same range of composition, and is suitable for the same uses as the coal of the Appalachian field south of the Pocahontas region, except that of Lookout Mountain in Georgia and Alabama. The region is as yet without adequate railroad facilities.

The rocks are in general nearly flat, and all coal beds that outcrop can be exploited by drift mines. The beds generally have a strong roof and stable floor. There is no reason to expect trouble from gas or water. Timber and water for mining purposes are abundant. Mining conditions therefore seem highly favorable and the region should, with development, become one of the principal coal-producing centers of the central Appalachian coal field.

INDEX

GREAT FALLS OF THE POTOMAC.

VIRGINIA GEOLOGICAL SURVEY

UNIVERSITY OF VIRGINIA

THOMAS LEONARD WATSON, PH. D.
DIRECTOR

Bulletin No. X

Surface Water Supply of Virginia

BY

G. C. STEVENS

PREPARED IN COÖPERATION WITH THE
UNITED STATES GEOLOGICAL SURVEY

CHARLOTTESVILLE
UNIVERSITY OF VIRGINIA
1916

J. P. BELL COMPANY
INCORPORATED
Printers
Designers
& Engravers
Lynchburg, Va.

STATE GEOLOGICAL COMMISSION

HENRY CARTER STUART, *Chairman,*
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President of the Virginia-Carolina Railway Company.

THOMAS L. WATSON,
Director of the Survey.

CONTENTS

ILLUSTRATIONS

LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, March 31, 1916.

Governor Henry C. Stuart, Chairman, and Members of the State Geological Commission:

GENTLEMEN:—I have the honor to transmit to you herewith, and to recommend for publication as Bulletin No. X of the Virginia Geological Survey Series of Reports, a manuscript and illustrations of a report on "Surface Water Supply of Virginia," by G. C. Stevens, of the U. S. Geological Survey.

Respectfully submitted,

THOMAS L. WATSON,
Director.

Surface Water Supply of Virginia

By G. C. STEVENS

INTRODUCTION.

This report contains the results of stream-flow investigations made by the United States Geological Survey in Virginia from 1906 to 1914 and forms a continuation of a report entitled "Hydrography of Virginia," prepared by the United States Geological Survey in 1906 and published by the State of Virginia as Geological Series, Bulletin III. The report was prepared from annual water-supply papers, unpublished data in the files of the United States Geological Survey, and data published in "Hydrography of Virginia," and includes the tables of monthly discharge which were published in the report last named, except for stations operated and discontinued prior to 1906. (See Plate V.)

The methods by which the base data were collected are those followed by the United States Geological Survey at current-meter gaging stations and described in standard textbooks. (See Plates II and III.)

DEFINITION OF TERMS.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups—(1) those which represent a rate of flow, as second-feet, gallons per minute, miner's inches, and discharge in second-feet per square mile, and (2) those which represent the actual quantity of water, as run-off in depth in inches, and acre-feet. The units used in this report are second-feet, second-feet per square mile, and run-off in depth in inches. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the unit for the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot a second. It is generally used as a fundamental unit from which others are computed.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off, depth in inches," is the depth to which a drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

The following terms not in common use may be defined as follows:

"Control," "controlling section," and "point of control" are terms used to designate the section or sections of the stream below the gage which determines the discharge relation at the gage. It should be noted that the control may not be the same cross section at all stages.

"Discharge relation" is an abbreviation for the term "relation of gage height to discharge."

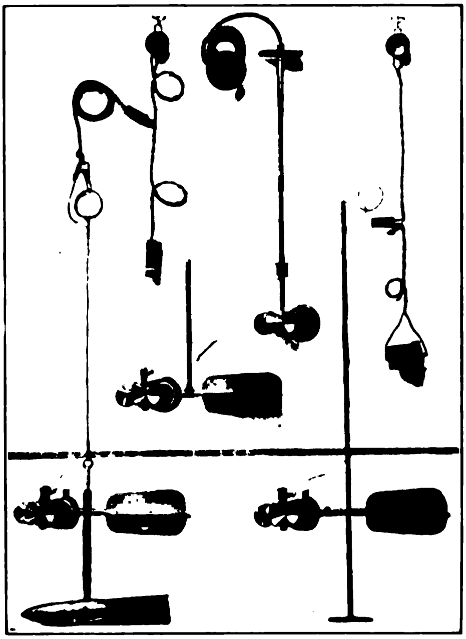
The "point of zero flow" for a given gaging station is that point on the gage—the gage height—to which the surface of the river would fall if there were no flow.

EXPLANATION OF DATA.

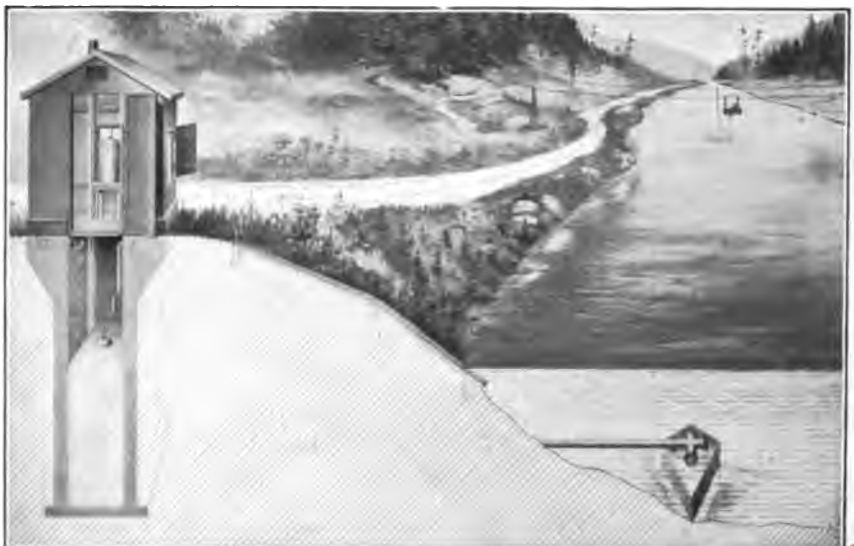
For each gaging station the following data, so far as available, are given: Description of the station, list of discharge measurements, table of daily gage heights, table of daily discharge, table of monthly and yearly discharge and run-off.

In addition to statements regarding the location and equipment of current-meter stations, the descriptions give information in regard to any conditions which may affect the constancy of the relation of gage height to discharge, covering such points as ice, shifting channels, and backwater; also information regarding operation of power plants which may affect the natural distribution of flow. Statements are also made regarding the accuracy of the data.

The table of daily gage height shows the daily fluctuations of the surface of the river, as found from the mean of the gage readings taken each day, usually in the morning and in the evening, though at many stations only one reading is made each day. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. All gage heights affected by the presence of ice in the streams or by backwater from obstructions are published as recorded, with suitable footnotes. The rating table is not applicable for such periods unless the proper corrections to the gage heights are known and applied. Attention is called to the fact that the zero of the gage is placed at an arbitrary datum and has no relation



A. **Price current meters.**



B. Typical cable gaging station with automatic gage.

to zero flow or the bottom of the river. In general the zero is located somewhat below the gage height of the lowest known flow, so that negative readings shall not occur.

The discharge measurements and gage heights are the base data from which rating tables, daily discharge tables, and monthly discharge tables are computed.

The rating table gives, either directly or by interpolation, the discharge in second-feet corresponding to every stage of the river recorded during the period for which it is applicable. It is not published in this report, but can be determined from the tables of daily gage heights and daily discharge by plotting gage heights in feet as ordinates and discharge in second-feet as abscissas.

The table of daily discharge, determined from the rating table and daily gage height table, gives the discharges in second-feet corresponding to the observed gage heights as determined from the rating tables.

In the table of monthly discharge the column headed "Maximum" gives the mean flow, as determined from the rating table, for the day when the mean gage height was highest. As the gage height is the mean for the day, it does not indicate correctly the stage when the water surface was at crest height and the corresponding discharge was consequently larger than given in the maximum column. Likewise in the column headed "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow in cubic feet for each second during the month. On this the computations for the remaining columns are based.

ACCURACY OF FIELD DATA AND COMPUTED RESULTS.

The accuracy of stream-flow data depends (1) on permanence of the relation between discharge and stage, and (2) on the accuracy of observations of stage, measurements of discharge, and interpretation of data.

In order to give engineers and others information regarding the probable accuracy of the computed results, footnotes are added to the daily discharge tables, stating the probable accuracy of the rating curves used, and an accuracy column is inserted in the monthly discharge table. For the rating curves, "well defined" indicates, in general, that the rating is probably accurate within 5 per cent; "fairly well defined," within 10 per cent; "poorly defined" or "approximate," within 15 to 25 per cent. These notes are very general and are based on the plotting of the individual measurements with reference to the mean rating curve.

The accuracy column in the monthly discharge table does not apply to the maximum or minimum nor to any individual day, but to the monthly mean. It is based on the accuracy of the rating, the probable reliability of the observer, the number of gage readings per day, the range of the fluctuation in stage, and knowledge of local conditions. In this column, A indicates that the mean monthly flow is probably accurate within 5 per cent; B, within 10 per cent; C, within 15 per cent; D, within 25 per cent. Special conditions are covered by footnotes.

ACKNOWLEDGMENTS.

For assistance rendered or records furnished as indicated under "Coöperation" in the station descriptions acknowledgments are due to the United States Forest Service, the United States Weather Bureau, the Potomac Electric Power Co., the Virginia Electrolytic Co., the Spottsylvania Power Co., the Roanoke Railway & Electric Co., and the Virginia Railway & Power Co.

A. For bridge measurement.

B. For wading measurement.

TYPICAL GAGING STATIONS.

STATION RECORDS.

POTOMAC RIVER BASIN.

POTOMAC RIVER AT POINT OF ROCKS, MD.

Location.—At the steel highway bridge at Point of Rocks, about one-third mile below Catoctin Creek, about 6 miles above Monocacy River, and about 30 miles above Great Falls. (See Plate I.)

Drainage area.—9,650 square miles.

Records available.—February 17, 1895, to December 31, 1914.

Gage.—Chain, attached to bridge; read once daily. Datum constant since September 2, 1902; prior to this date datum was 0.45 foot higher than at present. Datum is 200.54 feet above mean sea level.

Discharge measurements.—Made from the bridge.

Channel and control.—Practically permanent. The control is a ledge a few hundred feet below the station, the ledge extending completely across the river except for one relatively unimportant channel.

Extremes of discharge.—Maximum stage recorded 1895-1914: 29.0 feet, March 2, 1902; discharge 218,700 second-feet. Minimum stage recorded: 0.38 foot, September 10, 1914; discharge, 540 second-feet.

Winter flow.—Little affected by ice.

Canal.—The Chesapeake & Ohio canal parallels the Potomac on the Maryland side. The average discharge of the canal is 75 to 100 second-feet. The discharge is not included in the following tables.

Accuracy.—Results excellent except at extreme low water, when conditions for measuring are not good.

Discharge measurements of Potomac River at Point of Rocks, Md., for 1906–1914.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1906				1909			
May 30....	R. Follansbee	1.70	3,890	July 13...	Bolster and Stevens.	1.19	2,520
Dec. 7 [a]...	Bolster and Padgett.	1.76	4,450	Oct. 9....	Bolster and Mathers.	.54	871
1907				1913			
Mar. 15 [b].	R. H. Bolster	16.95	114,000	Aug. 13..	Batchelder and Padgett	1.34	3,170
1908				Aug. 29..	G. C. Stevens.......	.98	1,880
Jan. 14 [b]..	Bolster and Henshaw	15.50	108,000	1914			
May 26 [c]..	Follansbee and Walters	8.57	43,700	Nov. 7...	Stevens and Elwood	.65	1,180

[a] Results not reliable; heavy gale downstream.
[b] Surface velocities observed; coefficient of 0.95 used to reduce to mean velocity.
[c] Surface velocities observed; coefficient of 0.92 used to reduce to mean velocity.

Daily gage height, in feet, of Potomac River at Point of Rocks, Md., for 1906–1914.

[Geo. H. Hickman, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	3.6	3.0	1.9	11.1	3.3	1.8	2.2	1.6	3.7	1.2	2.6	1.9
2	3.4	2.9	1.8	9.6	3.1	1.7	1.9	1.5	3.1	1.2	2.5	1.8
3	3.3	2.7	1.8	7.7	2.8	1.7	2.0	1.5	2.8	1.4	2.3	1.9
4	3.7	2.5	2.0	6.5	2.8	1.6	2.9	4.3	2.6	1.5	2.3	1.7
5	8.0	2.4	4.0	5.5	2.6	1.5	2.6	3.6	2.3	2.2	2.1	1.8
6	8.6	2.2	5.45	5.1	2.5	1.7	2.4	2.8	2.1	2.5	2.1	1.8
7	7.0	2.2	4.5	4.8	2.6	1.9	2.2	2.4	1.9	2.7	2.1	1.85
8	4.8	2.0	3.6	4.8	2.5	1.7	2.0	2.6	1.8	2.6	2.0	1.7
9	4.0	1.9	3.0	4.3	2.4	2.4	1.9	2.8	1.8	2.5	2.0	1.75
10	3.5	1.8	2.7	4.2	2.4	3.0	1.7	3.2	1.7	2.2	1.9	1.8
11	3.1	1.8	2.6	5.5	2.4	2.5	1.5	7.6	1.7	2.0	1.8	2.0
12	2.9	1.9	2.5	5.6	2.2	2.2	1.4	5.7	1.6	1.9	1.8	2.2
13	2.8	1.8	2.3	4.9	2.3	1.8	1.8	4.3	1.6	1.6	1.8	3.5
14	3.0	1.8	2.3	4.0	2.2	1.6	1.2	3.7	1.5	1.5	1.7	3.1
15	3.3	1.9	2.3	5.75	2.0	1.6	1.3	3.0	1.5	1.6	1.8	2.65
16	3.6	1.8	2.4	8.45	2.1	1.6	1.2	5.1	1.4	1.4	1.7	2.7
17	3.7	1.7	2.5	7.5	2.0	1.6	1.2	4.8	1.6	1.4	1.8	2.8
18	4.1	1.6	2.5	6.3	1.8	2.5	1.5	4.2	1.5	1.5	1.8	4.7
19	3.9	1.6	2.6	5.1	1.9	3.2	1.8	3.5	1.4	1.7	1.9	10.0
20	3.5	1.6	2.9	4.5	1.8	2.9	1.7	4.4	1.4	12.5	1.9	7.2
21	3.4	1.7	2.9	4.1	1.6	3.1	1.5	4.0	1.4	16.1	8.0	5.6
22	3.3	1.8	3.1	3.6	1.6	5.0	1.4	5.8	1.8	11.65	4.2	5.2
23	3.2	1.9	3.4	3.3	1.6	4.3	1.5	4.8	1.8	8.5	4.0	4.6
24	3.1	2.0	3.9	3.1	1.4	3.6	2.0	3.7	1.3	6.6	3.3	3.8
25	6.35	2.0	3.9	2.9	1.5	3.1	2.1	4.1	1.3	5.4	3.0	3.2
26	5.1	1.9	3.9	2.9	1.4	2.6	1.9	4.8	1.3	4.5	2.7	2.8
27	4.2	1.8	3.7	2.8	1.3	2.4	1.7	4.6	1.2	4.1	2.6	2.85
28	3.6	2.0	7.8	5.1	1.9	2.3	1.8	6.7	1.2	3.6	2.2	2.9
29	3.4	....	12.9	5.0	1.9	3.1	1.9	6.0	1.2	3.3	2.1	3.0
30	3.2	....	10.5	4.3	1.7	3.0	2.0	5.3	1.2	3.1	2.1	3.1
31	3.1	....	10.9	....	1.7	....	1.7	4.4	....	2.8	....	3.2
1907												
1	7.1	3.0	3.1	3.0	3.2	2.6	2.7	1.7	1.5	2.3	1.2	3.2
2	7.9	2.9	3.6	2.8	3.1	3.2	2.7	1.7	1.4	2.2	1.5	2.9
3	7.0	3.1	4.6	2.7	3.0	14.6	2.6	1.6	1.4	2.2	1.6	2.7
4	5.5	3.0	5.3	2.7	2.9	10.5	2.5	1.6	1.8	2.1	2.5	2.6
5	4.6	2.9	5.8	2.6	2.7	8.7	2.4	1.5	2.5	2.0	2.4	2.4
6	4.0	2.9	4.5	2.5	2.6	6.5	2.2	1.5	2.1	2.0	2.3	2.3
7	3.8	2.8	4.4	2.5	2.6	6.0	2.2	1.4	1.9	1.9	2.3	2.2
8	3.5	2.8	4.0	2.7	2.5	5.1	2.1	1.4	1.8	1.8	2.2	2.1
9	3.4	2.8	3.6	3.8	2.7	5.0	2.0	1.4	1.7	1.7	2.6	2.1
10	3.6	2.8	3.6	9.5	6.05	5.8	1.9	1.5	1.6	1.6	2.5	2.5
11	3.7	3.0	3.5	8.6	7.7	5.6	2.0	1.5	1.6	1.6	2.4	7.0
12	3.7	3.0	3.5	6.5	5.5	5.2	2.5	1.6	1.5	1.6	2.3	7.5
13	5.0	3.0	5.1	5.4	4.8	5.4	2.3	1.7	1.5	1.5	2.2	6.0
14	9.5	3.1	13.4	5.0	4.3	5.2	2.2	1.7	1.6	1.5	2.1	5.2
15	10.7	3.3	17.0	4.5	3.7	6.1	2.0	1.6	1.8	1.5	2.0	4.7
16	9.4	3.4	14.1	4.0	3.5	7.5	1.9	1.6	1.9	1.4	1.9	4.5
17	7.5	3.7	8.6	3.5	3.3	6.6	1.8	1.5	1.7	1.4	1.8	4.3
18	6.9	3.8	7.6	3.4	3.1	6.2	2.0	1.5	1.6	1.4	1.7	4.0
19	6.2	3.9	7.2	3.3	3.0	5.6	2.8	1.5	1.6	1.3	1.8	3.7
20	8.5	3.7	10.3	3.3	2.9	5.1	3.4	1.4	2.0	1.3	2.0	3.3
21	12.0	3.6	12.4	3.2	2.8	4.6	2.9	1.4	2.9	1.3	2.1	3.1
22	9.5	3.4	9.2	3.2	3.0	4.3	2.7	1.4	2.8	1.2	2.2	3.0
23	7.0	3.1	7.9	3.2	2.7	3.6	2.5	1.5	2.9	1.2	2.3	3.0
24	6.2	2.7	6.2	3.3	2.5	3.2	2.2	1.9	3.6	1.2	2.5	4.9
25	5.4	2.6	4.8	4.0	2.6	3.0	2.0	2.0	6.1	1.2	3.8	11.7

Daily gage height, in feet, of Potomac River at Point of Rocks, Md., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	4.4	2.7	4.4	5.1	2.5	2.9	2.0	2.0	4.2	1.1	6.05	9.0
27	4.2	2.7	4.0	4.5	2.8	2.8	2.1	1.9	3.6	1.1	5.4	6.5
28	3.7	2.9	3.7	4.1	2.9	2.9	2.0	1.8	2.9	1.2	4.6	5.7
29	3.3	....	3.5	3.8	2.8	2.8	2.0	1.7	2.6	1.2	4.0	5.0
30	3.1	....	3.3	3.3	2.7	2.8	1.9	1.6	2.4	1.3	3.5	5.0
31	3.1	....	3.1	....	2.6	....	1.8	1.5	....	1.2	....	5.4
1908												
1	5.0	3.2	3.9	3.4	2.3	4.2	1.7	2.0	1.7	1.6	1.9	1.0
2	4.6	2.8	3.7	4.0	2.3	3.8	1.6	1.8	1.6	1.5	1.8	1.0
3	4.3	2.5	4.7	4.4	2.4	3.4	2.5	1.6	1.5	1.3	1.8	1.0
4	3.8	2.5	8.6	4.1	2.5	3.0	1.6	1.5	1.5	1.3	1.7	1.0
5	3.4	2.5	7.8	3.8	2.6	2.8	1.7	1.4	1.4	1.2	1.6	.9
6	3.3	2.6	8.0	3.7	5.8	3.5	1.7	1.4	1.4	1.2	1.5	.9
7	3.0	2.7	9.0	3.6	8.9	3.4	1.6	1.3	1.3	1.1	1.4	.8
8	2.8	2.8	11.4	3.4	15.0	3.0	1.6	1.3	1.2	1.1	1.3	.9
9	2.7	3.0	11.0	3.4	14.7	2.8	1.5	1.4	1.4	1.1	1.2	1.0
10	2.5	3.1	12.0	3.7	8.6	2.7	1.5	1.4	1.3	1.2	1.2	1.1
11	2.5	2.8	9.1	3.5	6.4	2.7	1.4	1.3	1.3	1.3	1.1	1.1
12	5.5	2.7	7.9	4.0	5.6	2.6	1.4	1.2	1.2	1.2	1.0	1.1
13	19.7	2.8	7.5	4.5	4.9	2.5	1.4	1.2	1.2	1.2	1.0	1.2
14	19.0	3.2	6.5	3.8	4.2	2.4	1.3	1.2	1.1	1.2	1.0	1.2
15	10.4	5.7	5.8	3.5	3.9	2.3	1.3	1.3	1.1	1.0	1.0	1.2
16	7.6	18.8	5.5	3.2	3.6	2.5	1.3	1.2	1.1	1.0	1.0	1.2
17	6.3	18.3	5.1	2.9	3.6	2.4	1.3	2.25	1.0	1.0	1.0	1.2
18	5.6	12.4	4.7	2.9	3.7	2.3	1.2	1.8	1.0	1.0	1.1	1.2
19	5.1	9.5	4.2	2.9	4.6	2.2	1.3	1.6	1.0	.9	1.1	1.1
20	4.5	5.7	7.6	2.7	5.8	2.2	1.3	1.5	.9	.9	1.1	1.2
21	4.2	5.0	7.4	2.7	10.9	2.1	1.3	1.5	.9	1.0	1.1	1.3
22	4.0	4.5	5.8	2.7	11.1	2.1	1.6	1.4	.9	1.0	1.1	1.3
23	4.2	4.1	5.0	2.5	18.1	2.0	2.0	1.3	.8	1.0	1.2	1.4
24	4.8	3.8	4.4	2.6	10.1	2.0	1.7	1.4	.8	1.0	1.2	1.5
25	5.2	3.4	4.2	2.5	8.4	2.0	1.7	1.5	.8	1.0	1.2	1.4
26	5.6	5.2	3.9	2.3	6.5	1.9	2.1	1.8	.8	2.2	1.2	1.4
27	5.0	5.9	3.4	2.4	5.5	1.9	2.5	2.8	.9	2.0	1.1	1.4
28	4.6	5.0	3.3	2.4	5.3	1.8	3.4	2.75	.9	1.8	1.1	1.3
29	4.3	4.1	3.3	2.2	4.8	1.8	3.4	2.4	1.6	1.7	1.1	1.3
30	3.9	....	3.2	2.3	4.4	1.7	3.0	2.1	1.7	1.6	1.1	1.2
31	3.6	....	3.4	....	4.2	....	3.4	1.9	....	1.8	....	1.2
1909												
1	1.4	2.2	4.1	2.3	3.3	2.3	2.6	0.7	0.9	0.78	1.1	0.9
2	1.6	2.0	3.8	2.3	3.2	2.1	2.4	.8	.85	.75	1.05	.95
3	1.6	1.9	3.6	2.2	3.1	2.1	2.1	.9	.8	.7	1.0	.9
4	1.5	1.9	3.5	2.2	3.0	3.25	1.9	.95	.8	.65	.95	.91
5	1.5	1.8	4.1	2.2	2.9	3.0	1.7	1.05	.75	1.0	.85	.95
6	1.9	1.8	3.8	2.2	2.8	2.9	1.6	1.05	.8	.9	.9	.9
7	2.6	1.9	3.7	2.1	2.7	5.0	1.5	1.05	.85	.85	.95	.9
8	2.4	1.9	3.5	2.1	2.6	4.4	1.4	1.0	.9	.8	.9	1.0
9	2.2	2.0	3.4	2.1	2.4	3.5	1.3	.95	.85	.6	.95	1.1
10	2.0	2.2	3.4	2.0	2.3	3.3	1.2	.9	.95	.85	1.05	1.2
11	1.9	3.1	3.3	2.0	2.3	3.7	1.2	1.0	.95	.6	1.0	1.55
12	1.8	4.3	3.3	2.0	2.7	4.6	1.2	1.0	.9	1.05	.95	1.4
13	1.7	4.2	3.3	1.9	2.6	4.2	1.2	.95	.9	.95	.8	1.35
14	1.7	3.7	3.1	2.8	2.5	3.9	1.15	.9	.85	1.1	.85	1.4
15	1.6	3.3	2.9	4.6	2.4	3.4	1.2	.85	.85	1.4	.8	2.45
16	1.7	3.4	2.8	12.25	2.3	3.8	1.2	.98	1.1	1.5	1.05	2.45
17	1.6	3.3	2.7	7.1	2.1	3.4	1.0	1.4	1.15	1.4	.95	2.41
18	2.4	3.5	2.5	5.5	2.1	3.4	1.0	1.2	1.0	1.2	.9	2.2
19	2.3	3.5	2.4	4.4	2.0	4.9	1.0	1.75	1.0	1.15	.95	1.7
20	2.2	3.4	2.3	3.8	2.1	4.4	1.0	1.55	1.0	1.05	.9	1.4

Daily gage height, in feet, of Potomac River at Point of Rocks, Md., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	2.2	3.4	2.2	3.7	2.1	3.7	.9	1.4	.95	1.0	.95	1.35
22	2.1	3.4	2.1	7.2	2.2	2.8	.9	1.2	1.0	1.0	.95	1.4
23	2.2	3.5	2.1	6.9	4.2	2.5	.9	1.15	.95	.95	1.0	1.4
24	3.0	4.0	2.1	6.8	5.8	2.6	.8	1.1	1.05	.95	1.05	1.35
25	4.2	6.8	2.0	6.6	4.4	2.4	.8	1.05	1.0	1.0	1.0	1.3
26	6.5	6.5	2.0	6.4	3.8	2.2	.8	1.0	.95	1.7	.95	1.35
27	4.3	5.4	2.0	6.0	3.4	2.3	.8	.95	.9	2.0	.85	1.4
28	3.7	4.6	2.1	5.2	3.0	3.5	.8	.9	.9	1.55	.9	1.65
29	3.0	....	2.2	4.4	2.8	3.6	.8	.8	.85	1.3	.9	1.6
30	2.7	....	2.2	3.4	2.6	3.5	.9	.8	.8	1.25	.95	1.4
31	2.4	....	2.3	....	2.5	....	.8	.9	....	.95	....	1.7
1910												
1	1.65	2.5	5.4	1.5	3.6	1.65	2.3	1.2	0.80	0.81	0.80	0.85
2	1.6	2.4	7.1	1.5	3.3	1.6	2.4	1.2	.80	.80	.85	.80
3	1.55	2.2	7.0	1.55	3.0	1.65	2.1	1.25	.81	.80	.81	.75
4	1.35	2.1	6.4	1.6	2.7	1.65	2.0	1.3	1.0	.81	.80	.80
5	1.35	2.2	5.1	1.65	2.4	1.6	2.0	1.4	1.35	.76	.80	.85
6	3.8	2.0	4.6	1.6	2.2	1.8	2.4	1.25	1.3	.80	.82	1.05
7	3.5	2.1	4.0	1.6	2.1	1.75	2.4	1.2	1.2	.76	.77	1.05
8	3.0	2.4	3.7	1.55	2.0	1.7	2.3	1.1	1.15	.85	.76	.95
9	3.3	2.2	3.4	1.55	2.0	1.7	2.6	1.05	1.05	.86	.70	.95
10	3.2	2.1	3.2	1.5	1.95	1.9	2.4	1.0	.96	.80	.81	1.05
11	3.2	2.2	3.0	1.45	1.95	2.1	2.2	.95	.92	.85	.80	1.0
12	3.0	1.8	2.7	1.4	1.95	4.2	2.2	.92	.90	.91	.80	1.0
13	2.6	1.85	2.3	1.4	1.9	6.3	2.3	.91	.90	.85	.75	1.05
14	2.5	1.95	2.3	1.35	1.85	6.8	2.4	.91	.91	.90	.72	1.0
15	2.3	2.0	2.2	1.3	1.8	6.1	2.6	.95	.91	.85	.75	1.0
16	2.4	2.2	2.2	1.3	1.75	5.9	2.4	1.0	.90	.80	.76	1.0
17	2.4	3.3	2.2	1.4	1.7	15.3	2.4	1.05	.90	.81	.80	1.05
18	2.4	8.2	2.2	1.65	1.7	22.0	2.2	.95	.90	.76	.81	1.0
19	4.0	8.6	2.1	4.3	1.65	13.5	2.2	.91	.85	.75	.72	.95
20	4.0	7.0	2.0	4.8	1.65	13.2	3.0	.90	.75	.80	.70	1.0
21	8.0	5.6	1.95	4.5	1.65	10.4	2.3	.91	.80	.80	.75	1.5
22	13.5	4.1	1.9	4.1	1.85	6.9	2.2	.92	.80	.85	.75	1.35
23	10.5	7.8	1.85	3.8	1.75	6.4	2.0	.91	.75	.80	.72	1.15
24	7.2	7.0	1.8	3.5	1.7	4.9	1.75	.91	.76	.75	.70	1.1
25	4.7	5.2	1.75	3.8	1.85	4.0	1.6	.90	.75	.85	.80	1.1
26	3.7	4.0	1.65	7.6	2.2	3.6	1.55	.90	.55	1.05	.95	1.2
27	3.1	3.6	1.6	7.4	2.9	3.4	1.55	.90	.80	.95	.85	1.1
28	3.0	3.65	1.5	6.8	2.4	2.8	1.55	.85	.85	.90	.80	1.05
29	3.0	....	1.5	4.9	2.1	2.6	1.6	.80	.80	.85	.81	1.05
30	3.0	....	1.5	4.1	1.9	2.5	1.25	.80	.80	.80	.81	1.1
31	2.8	....	1.5	....	1.75	....	1.25	.81	....	.81	....	1.2
1911												
1	1.0	10.5	3.1	2.6	2.6	1.25	1.7	0.68	14.6	2.2	1.85	1.9
2	1.85	6.0	3.2	2.6	2.8	1.3	1.4	.63	11.4	2.4	1.8	1.85
3	2.8	5.0	3.0	2.5	2.8	1.25	1.3	.63	5.9	2.1	1.7	1.75
4	7.0	5.0	2.7	2.6	2.8	1.25	1.2	.65	4.0	2.2	1.55	1.8
5	6.5	3.5	2.4	2.8	2.5	1.35	1.1	.95	3.8	3.0	1.4	1.8
6	5.6	3.3	2.3	7.4	2.4	1.3	1.05	1.25	2.6	2.4	1.35	1.65
7	4.1	3.0	2.2	9.5	2.2	1.25	1.0	1.15	2.3	2.2	1.7	1.7
8	3.5	2.8	2.1	7.5	2.1	1.25	1.3	1.1	2.0	1.7	2.7	1.65
9	2.6	2.6	2.0	5.6	2.0	1.35	1.7	.90	1.85	2.0	3.8	1.6
10	2.2	2.5	2.5	5.1	1.95	1.25	1.3	.95	1.7	3.2	3.4	1.55
11	2.1	2.4	2.3	5.0	1.9	1.7	1.45	.95	2.1	2.6	3.0	1.5
12	1.85	2.3	3.0	4.7	1.85	1.65	1.35	.85	2.0	2.3	2.6	1.5
13	1.85	2.3	4.5	4.6	1.75	1.55	1.2	.92	1.85	2.2	2.5	1.5
14	2.0	2.4	4.6	4.6	1.7	1.5	1.2	.65	1.65	2.2	2.4	1.5
15	5.1	2.8	4.7	4.5	1.65	1.5	1.2	.80	1.8	2.1	2.4	1.55

Daily gage height, in feet, of Potomac River at Point of Rocks, Md., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
16	4.6	3.3	4.6	4.4	1.6	1.5	1.0	.75	2.1	2.0	2.1	2.0
17	4.0	3.4	4.5	4.0	1.6	1.5	1.3	.70	5.6	1.85	2.1	2.7
18	3.3	3.0	4.3	3.6	1.55	1.15	1.05	.75	4.6	2.6	2.1	5.2
19	2.7	2.8	3.7	3.4	1.5	1.35	.95	.90	3.5	5.0	2.1	4.4
20	2.4	3.0	3.4	3.3	1.45	1.6	.85	.80	2.9	7.1	2.3	3.2
21	2.2	2.6	3.3	3.2	1.4	2.7	.80	.70	2.5	5.1	2.4	2.9
22	2.1	2.6	3.2	3.2	1.35	1.95	.90	.65	2.3	3.8	2.5	2.4
23	2.0	2.4	3.1	3.1	1.35	1.7	.85	.60	2.0	3.6	2.3	1.8
24	2.1	2.4	3.0	3.2	....	1.5	.75	.65	2.0	3.2	2.3	5.0
25	2.2	2.3	2.8	3.2	....	1.35	.85	.70	1.9	2.9	2.2	5.8
26	2.7	2.2	2.6	3.3	....	1.7	.72	.78	1.75	2.7	2.0	5.2
27	2.6	2.8	2.4	3.2	....	1.6	.80	1.2	1.65	2.4	2.2	5.4
28	2.9	3.0	2.4	3.2	....	2.6	.65	1.05	1.55	2.3	2.0	6.5
29	4.4	....	2.5	3.0	1.15	2.35	.45	.90	1.6	2.1	1.95	6.1
30	4.9	....	2.6	2.6	1.1	2.0	.60	1.65	1.55	2.0	1.95	4.9
31	10.2	....	2.5	....	1.1	....	.60	6.0	....	1.9	....	4.4
1912												
1	4.5	3.3	5.9	7.6	3.6	2.3	2.5	2.5	0.86	2.5	1.25	1.05
2	5.2	3.2	4.8	6.7	3.5	2.1	2.3	2.7	1.1	2.3	1.25	1.15
3	5.0	3.2	4.1	5.6	3.4	2.3	2.2	2.6	1.35	2.1	1.2	1.05
4	4.6	3.0	3.6	5.4	3.3	2.1	2.5	1.9	1.5	1.85	1.1	1.1
5	3.8	2.8	3.3	4.9	2.8	2.0	1.9	1.8	1.35	1.65	1.1	1.2
6	2.4	2.8	3.2	4.8	2.7	2.1	1.8	1.55	2.0	1.5	1.15	1.4
7	2.3	2.8	3.0	4.5	2.6	2.2	1.85	1.4	1.8	1.65	1.15	1.45
8	2.1	2.8	2.8	3.8	4.5	2.0	1.95	1.35	1.25	1.55	1.8	1.3
9	1.9	2.6	2.8	3.6	4.6	1.8	1.85	1.6	1.2	1.35	....	1.6
10	4.7	2.5	3.0	3.4	4.0	1.85	1.75	1.45	1.25	1.3	2.6	1.65
11	5.0	2.6	3.2	3.0	3.5	1.65	1.7	1.35	1.15	1.25	2.4	1.7
12	4.9	2.6	3.0	3.0	4.6	1.75	1.8	1.55	1.1	1.15	2.3	1.75
13	4.8	2.6	3.6	2.6	8.8	1.85	1.9	1.6	1.05	1.05	1.8	1.45
14	4.4	2.4	4.4	2.6	11.6	1.6	1.65	1.7	1.15	1.45	1.65	1.3
15	4.4	2.5	5.9	3.0	7.6	1.75	1.95	1.6	.96	1.2	1.6	1.15
16	4.3	2.7	12.0	3.0	6.3	2.6	1.7	1.35	1.0	1.15	1.45	1.45
17	4.3	2.7	13.0	2.9	9.0	2.3	1.65	1.3	.91	1.2	1.45	1.55
18	4.3	2.6	8.7	3.8	11.1	2.4	2.8	1.35	.96	1.05	1.45	1.5
19	4.3	2.9	6.5	4.7	7.0	2.3	2.4	1.25	1.0	1.15	1.4	1.6
20	4.5	3.0	5.8	6.0	6.3	2.3	2.3	1.3	1.0	1.2	1.3	1.55
21	4.0	3.2	5.7	4.8	5.0	2.0	3.0	1.25	.96	1.25	1.2	1.5
22	4.0	4.0	10.4	4.4	4.0	1.85	3.2	1.3	1.05	1.15	1.15	1.35
23	4.9	5.7	9.3	4.0	3.8	1.85	3.5	1.25	1.05	1.2	1.15	1.45
24	4.8	8.2	7.1	3.6	3.5	2.0	3.6	1.2	3.1	1.2	1.1	1.5
25	4.7	6.6	7.9	3.4	3.3	2.2	3.0	1.2	7.4	1.15	1.15	1.45
26	4.7	6.8	8.0	3.2	3.0	2.2	8.8	1.2	7.9	1.05	1.2	1.55
27	4.7	12.6	6.8	3.2	2.9	2.1	5.7	1.2	5.1	1.2	1.05	1.55
28	4.0	13.0	5.9	3.3	2.6	2.1	4.1	1.2	3.5	1.3	1.15	1.6
29	3.9	8.6	6.3	3.4	2.5	2.3	3.1	1.2	3.3	1.25	1.1	1.65
30	3.4	....	9.7	3.5	2.4	2.1	2.9	1.05	2.9	1.2	1.05	1.7
31	3.4	....	9.9	....	2.3	....	2.6	1.1	....	1.25	....	2.8
1913												
1	3.8	2.8	1.45	5.2	2.5	9.4	2.8	1.55	0.85	1.15	2.5	2.2
2	4.4	2.7	1.4	4.6	2.3	6.0	2.5	1.65	.74	....	2.1	1.95
3	6.4	2.8	1.5	4.1	2.2	5.1	1.8	1.85	.92	1.75	2.1	2.0
4	3.9	2.6	1.7	3.8	2.2	4.2	1.7	2.0	.79	1.45	1.95	2.0
5	3.9	2.6	1.65	3.8	2.2	5.6	1.75	1.85	.76	1.2	1.7	2.1
6	3.8	2.6	1.6	3.6	2.2	4.9	1.9	1.85	.78	1.4	1.6	2.0
7	3.6	2.5	1.55	3.0	2.1	4.0	2.0	1.8	.79	1.1	1.55	2.5
8	3.9	2.4	1.55	3.0	2.0	3.2	1.9	1.65	.74	1.05	1.45	3.2
9	5.7	2.5	1.55	2.8	2.0	3.3	1.95	1.6	.89	1.05	1.75	4.1
10	5.3	2.6	1.6	2.8	1.8	2.9	1.6	1.45	.74	1.1	8.9	3.8

Daily gage height, in feet, of Potomac River at Point of Rocks, Md., for 1906-1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	4.4	2.4	1.55	2.8	1.85	3.1	1.5	1.35	.63	1.05	9.7	3.1
12	4.4	2.5	1.5	2.7	1.7	2.9	2.9	1.45	.66	.84	5.9	2.7
13	4.0	2.3	2.0	3.3	1.65	2.8	2.5	1.3	.73	1.95	4.4	2.6
14	3.9	2.3	3.1	5.0	1.6	2.6	2.3	1.2	.74	1.8	3.2	2.5
15	3.4	2.3	4.9	6.1	1.75	2.3	1.9	1.25	.48	1.6	3.3	2.4
16	3.0	2.2	6.4	6.8	1.6	2.0	1.7	1.25	.78	1.4	4.5	2.2
17	2.9	2.1	6.9	10.8	1.85	2.0	1.55	1.0	.64	1.35	6.2	2.2
18	2.8	2.0	5.2	8.1	2.0	2.7	1.9	1.4	.78	1.4	6.2	1.95
19	3.0	1.95	4.4	5.6	2.3	2.2	2.0	1.6	.74	.93	5.4	1.9
20	2.9	1.95	3.8	5.1	2.4	1.5	1.9	1.2	.89	1.25	5.6	1.8
21	2.6	1.9	3.3	4.5	2.3	1.25	1.8	1.15	.93	1.5	4.4	1.75
22	2.5	1.85	3.2	4.0	2.3	1.45	1.7	1.05	1.2	2.5	3.4	1.9
23	2.4	1.85	2.8	3.6	2.2	1.6	1.55	1.35	1.3	2.9	2.8	2.0
24	2.4	1.85	2.8	3.2	3.0	1.55	1.5	1.2	1.35	2.7	2.4	2.0
25	2.3	1.85	2.2	3.0	9.2	1.35	1.55	1.1	1.65	2.6	3.5	1.95
26	2.5	1.65	2.4	2.9	6.9	2.1	1.4	1.05	1.45	4.5	2.6	2.1
27	2.6	1.55	5.8	3.0	5.2	2.7	1.45	1.1	1.2	8.4	2.3	5.7
28	2.7	1.5	17.5	3.0	10.5	1.55	1.4	1.1	.98	5.9	2.2	4.9
29	2.8	....	16.0	3.0	11.3	2.3	1.35	1.05	.98	4.4	2.1	4.4
30	2.6	....	9.5	2.8	7.7	3.0	1.3	.88	.99	3.4	2.1	3.8
31	2.6	....	6.3	....	6.0	....	1.35	.86	....	2.8	....	3.4
1914												
1	3.0	6.4	3.0	4.8	4.9	1.9	1.6	0.79	1.25	0.77	0.52	0.64
2	....	7.9	2.9	4.6	4.5	1.85	1.5	.87	1.05	.60	.63	.69
3	3.3	6.7	2.9	4.5	4.0	1.5	1.4	1.15	1.05	.56	.66	.81
4	7.1	5.4	2.2	4.4	3.7	1.4	1.45	1.25	1.0	.52	.64	.90
5	8.7	4.8	3.3	4.4	3.4	1.35	1.3	.92	.98	.46	.71	.74
6	6.7	4.2	3.1	4.2	4.3	1.3	1.35	.65	.91	.64	.81	1.15
7	5.6	4.9	2.9	4.1	5.5	1.25	1.45	.60	.79	.66	.64	1.55
8	4.9	4.8	3.2	4.0	4.9	1.2	1.45	.49	.70	.46	.65	3.8
9	4.8	4.7	3.2	4.2	3.1	1.35	1.45	.76	.49	.69	.81	4.3
10	4.4	4.6	3.2	4.3	4.6	1.5	1.4	.87	.38	.76	.69	3.8
11	....	4.1	3.1	4.6	4.0	1.45	1.35	.98	.42	.67	.54	3.6
12	6.2	3.9	3.2	3.8	3.9	1.35	1.15	.93	.69	.58	.49	3.5
13	5.7	2.9	3.2	3.6	3.6	1.25	1.35	.87	.64	.56	.45	3.6
14	5.6	2.5	3.3	3.3	3.3	1.15	1.2	.84	.60	.58	.43	2.9
15	4.1	2.2	3.6	3.0	3.0	1.15	1.15	.80	.56	.54	.47	2.8
16	3.6	2.3	3.4	4.1	2.7	1.15	1.05	.83	.71	.47	.58	1.6
17	3.5	2.5	9.1	8.2	2.6	1.05	2.2	.78	.65	.66	.69	1.55
18	3.5	2.5	10.6	7.1	2.6	1.2	2.7	.64	.64	1.1	....	1.45
19	3.2	2.4	11.4	6.2	2.4	1.25	1.8	.92	.56	1.15	1.35	1.55
20	3.1	3.0	8.5	5.1	2.2	1.25	1.7	.76	.59	1.3	1.25	1.55
21	2.8	5.2	6.8	4.9	2.0	1.35	1.6	.82	.63	1.05	1.15	1.7
22	3.2	6.1	5.4	4.7	2.0	1.4	1.4	.85	.69	1.0	1.2	1.8
23	6.4	5.1	5.1	5.5	1.9	1.5	1.1	.71	.57	.98	1.25	1.85
24	5.2	4.3	4.8	5.0	1.9	1.55	.98	.79	.71	.92	1.3	2.4
25	5.4	3.9	4.4	4.2	1.95	1.55	1.2	.86	.76	.79	1.05	2.9
26	....	3.5	4.3	5.5	1.7	1.25	1.3	1.15	.67	.71	.97	3.0
27	6.9	3.6	4.6	8.2	1.4	1.9	1.1	1.05	.63	.97	.89	2.1
28	5.7	3.5	4.4	9.6	1.6	1.6	.96	.98	.57	.99	.87	2.2
29	5.1	....	....	6.7	1.5	1.7	.71	1.15	.53	.98	.83	1.8
30	5.0	....	6.0	5.9	1.6	1.95	.58	1.4	.66	.91	.79	1.9
31	5.3	....	5.1	....	1.5	....	.93	1.5	....	.47	....	1.85

NOTE.—Discharge relation affected by ice during the following periods: Dec. 22, 1909, to Jan. 20, 1910; Jan. 10-29 and Feb. 23-26, 1912. Discharge relation probably not seriously affected by ice at other periods during which ice was present.

Daily discharge, in second-feet, of Potomac River at Point of Rocks, Md., for 1906–1914.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	11,980	9,070	4,670	64,730	10,480	4,330	5,750	3,700	12,490	2,530	7,330	4,870
2	10,970	8,620	4,330	52,360	9,530	4,010	4,670	3,400	9,530	2,530	6,920	4,330
3	10,480	7,750	4,330	37,780	8,180	4,010	5,020	3,400	8,180	3,100	6,130	4,670
4	12,490	6,920	5,020	29,440	8,180	3,700	8,620	1,570	7,330	3,400	6,130	4,010
5	39,980	6,520	14,070	22,920	7,330	3,400	7,330	11,980	6,130	5,750	5,880	4,330
6	44,500	5,750	22,610	20,440	6,920	4,010	6,520	8,180	5,380	6,920	5,380	4,330
7	32,820	5,750	16,850	18,610	7,330	4,670	5,750	6,520	4,670	7,750	5,380	4,500
8	18,610	5,020	11,980	18,610	6,920	4,010	5,020	7,330	4,330	7,330	5,020	4,010
9	14,070	4,670	9,070	15,710	6,520	6,520	4,670	8,180	4,330	6,920	5,020	4,170
10	11,470	4,330	7,750	15,150	6,520	9,070	4,010	10,000	4,010	5,750	4,670	4,330
11	9,530	4,330	7,330	22,920	6,520	6,920	3,400	37,060	4,010	5,020	4,330	5,020
12	8,620	4,670	6,920	23,560	5,750	5,750	3,100	24,200	3,700	4,670	4,330	5,750
13	8,180	4,330	6,130	19,210	6,130	4,330	2,810	15,710	3,700	3,700	4,330	11,500
14	9,070	4,330	6,130	14,070	5,750	3,700	2,530	12,490	3,400	3,400	4,010	9,530
15	10,480	4,670	6,130	24,520	5,020	3,700	2,810	9,070	3,400	3,700	4,330	7,540
16	11,980	4,330	6,520	43,360	5,380	3,700	2,530	20,440	3,100	3,100	4,010	7,750
17	12,490	4,010	6,920	36,340	5,020	3,700	2,530	18,610	3,700	3,100	4,330	8,180
18	14,610	3,700	6,920	28,120	4,330	6,920	3,400	15,150	3,400	3,400	4,330	18,000
19	13,530	3,700	7,330	20,440	4,670	10,000	4,330	11,470	3,100	4,010	4,670	55,600
20	11,470	3,700	8,620	16,850	4,330	8,620	4,010	16,270	3,100	76,400	4,670	34,200
21	10,970	4,010	8,620	14,610	3,700	9,530	3,400	14,070	3,100	106,000	9,070	23,600
22	10,480	4,330	9,530	11,980	3,700	19,820	3,100	21,680	2,810	69,300	15,200	21,100
23	10,000	4,670	10,970	10,480	3,700	15,710	3,400	18,610	2,810	43,700	14,100	17,400
24	9,530	5,020	13,530	9,530	3,100	11,980	5,020	12,490	2,810	30,100	10,500	13,000
25	28,450	5,020	13,530	8,620	3,400	9,530	5,380	14,610	2,810	22,300	9,070	10,000
26	20,400	4,670	13,530	8,620	3,100	7,330	4,670	18,610	2,810	16,800	7,750	8,180
27	15,150	4,330	12,490	8,180	2,810	6,520	4,010	17,430	2,530	14,600	7,330	8,400
28	11,980	5,020	38,500	20,440	4,670	6,130	4,330	30,780	2,530	12,000	5,750	8,620
29	10,970	....	79,670	19,820	4,670	9,530	4,670	26,140	2,530	10,500	5,380	9,070
30	10,000	....	59,750	15,710	4,010	9,070	5,020	21,680	2,530	9,530	5,380	9,580
31	9,530	....	63,070	....	4,010	....	4,010	16,270	....	8,180	....	10,000
1907												
1	33,500	9,070	9,530	9,070	10,000	7,330	7,750	4,010	3,400	6,130	2,530	10,000
2	39,200	8,620	12,000	8,180	9,530	10,000	7,750	4,010	3,100	5,750	3,400	8,620
3	32,800	9,530	17,400	7,750	9,070	93,800	7,330	3,700	3,100	5,750	3,700	7,750
4	22,900	9,070	21,700	7,750	8,620	59,800	6,920	3,700	2,810	5,380	6,920	7,330
5	17,400	8,620	24,800	7,330	7,750	45,300	6,520	3,400	6,920	5,020	6,520	6,520
6	14,100	8,620	16,800	6,920	7,330	29,400	5,750	3,400	5,380	5,020	6,130	6,180
7	13,000	8,180	16,300	6,920	7,330	26,100	5,750	3,100	4,670	4,670	6,130	5,750
8	11,500	8,180	14,100	7,750	6,920	20,400	5,380	3,100	4,330	4,330	5,750	5,380
9	11,000	8,180	12,000	13,000	7,750	19,800	5,020	3,100	4,010	4,010	7,330	5,380
10	12,000	8,180	12,000	51,600	26,500	24,800	4,670	3,400	3,700	3,700	6,920	6,920
11	12,500	9,070	11,500	44,500	37,800	23,600	5,020	3,400	3,700	3,700	6,520	32,800
12	12,500	9,070	11,500	29,400	22,900	21,100	6,920	3,700	3,400	3,700	6,130	36,300
13	19,800	9,070	20,400	22,300	18,600	22,300	6,130	4,010	3,400	3,400	5,750	26,100
14	51,600	9,530	83,800	19,800	15,700	21,100	5,750	4,010	3,700	3,400	5,380	21,100
15	61,400	10,500	114,000	16,800	12,500	26,800	5,020	3,700	4,330	3,400	5,020	18,000
16	50,800	11,000	89,600	14,100	11,500	36,300	4,670	3,700	4,670	3,100	4,670	16,800
17	36,300	12,500	44,500	11,500	10,500	30,100	4,330	3,400	4,010	3,100	4,330	15,700
18	32,100	13,000	37,100	11,000	9,530	27,500	5,020	3,400	3,700	3,100	4,010	14,100
19	27,500	13,500	34,200	10,500	9,070	23,600	6,130	3,400	3,700	2,810	4,330	12,500
20	43,700	12,500	58,100	10,500	8,620	20,400	11,000	3,100	5,020	2,810	5,020	10,500
21	72,200	12,000	75,500	10,000	8,180	17,400	8,620	3,100	8,620	2,810	5,380	9,530
22	51,600	11,000	49,200	10,000	9,070	15,700	7,750	3,100	6,130	2,530	5,750	9,070
23	32,800	9,530	39,200	10,000	7,750	12,000	6,920	3,400	8,620	2,530	6,130	9,070
24	27,500	7,750	27,500	10,500	6,920	10,000	5,750	4,670	12,000	2,530	6,920	19,200
25	22,300	7,330	18,600	14,100	7,330	9,070	5,020	5,020	26,800	2,530	13,000	69,700

Daily discharge, in second-feet, of Potomac River at Point of Rocks, Md., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	16,300	7,750	16,300	20,400	6,920	8,620	5,020	5,020	15,200	2,260	26,500	47,600
27	15,200	7,730	14,100	16,800	8,180	8,180	5,380	4,670	12,000	2,260	22,300	29,400
28	12,500	8,620	12,500	14,600	8,620	8,620	5,020	4,330	8,620	2,530	17,400	24,200
29	10,500	....	11,470	13,000	8,180	8,180	5,020	4,010	7,330	2,530	14,100	19,800
30	9,530	....	10,500	10,500	7,750	8,180	4,670	3,700	6,520	2,810	11,500	19,800
31	9,530	....	9,530	....	7,330	....	4,330	3,400	....	2,530	....	22,300
1908												
1	19,800	10,000	13,500	11,000	6,130	15,200	4,010	5,020	4,010	3,700	4,670	2,000
2	17,400	8,180	12,500	14,100	6,130	13,000	3,700	4,330	3,700	3,400	4,330	2,000
3	15,700	6,920	18,000	16,300	6,520	11,000	6,920	3,700	3,400	2,810	4,330	2,000
4	13,000	6,920	44,500	14,600	6,920	9,070	3,700	3,400	3,400	2,810	4,010	2,000
5	11,000	6,920	38,500	13,000	7,330	8,180	4,010	3,100	3,100	2,530	3,700	1,750
6	10,500	7,330	40,000	12,500	24,800	11,500	4,010	3,100	3,100	2,530	3,400	1,750
7	9,070	7,750	47,600	12,000	46,800	11,000	3,700	2,810	2,810	2,260	3,100	1,520
8	8,180	8,180	67,200	11,000	97,100	9,070	3,700	2,810	2,530	2,260	2,810	1,750
9	7,750	9,070	63,900	11,000	94,600	8,180	3,400	3,100	3,100	2,260	2,530	2,000
10	6,920	9,530	72,200	12,500	44,500	7,750	3,400	3,100	2,810	2,530	2,530	2,260
11	6,920	8,180	48,400	11,500	28,800	7,750	3,100	2,810	2,810	2,810	2,260	2,260
12	22,900	7,750	39,200	14,100	23,600	7,330	3,100	2,530	2,530	2,530	2,000	2,260
13	136,000	8,180	36,300	16,800	19,200	6,920	3,100	2,530	2,530	2,530	2,000	2,530
14	130,000	10,000	29,400	13,000	15,200	6,520	2,810	2,530	2,260	2,530	2,000	2,530
15	58,900	24,200	24,800	11,500	13,500	6,130	2,810	2,810	2,260	2,000	2,000	2,530
16	37,100	129,000	22,900	10,000	12,000	6,920	2,810	2,530	2,260	2,000	2,000	2,530
17	28,100	124,000	20,400	8,620	12,000	6,520	2,810	5,940	2,000	2,000	2,000	2,530
18	23,600	75,500	18,000	8,620	12,500	6,130	2,530	4,330	2,000	2,000	2,260	2,530
19	20,400	51,600	15,200	8,620	17,400	5,750	2,810	3,700	2,000	1,750	2,260	2,260
20	16,800	24,200	37,100	7,750	24,800	5,750	2,810	3,400	1,750	1,750	2,260	2,530
21	15,200	19,800	35,600	7,750	63,100	5,380	2,810	3,400	1,750	2,000	2,260	2,810
22	14,100	16,800	24,800	7,750	64,700	5,380	3,700	3,100	1,750	2,000	2,260	2,810
23	15,200	14,600	19,800	6,920	123,000	5,020	5,020	2,810	1,520	2,000	2,530	3,100
24	18,600	13,000	16,300	7,330	56,400	5,020	4,010	3,100	1,520	2,000	2,530	3,400
25	21,100	11,000	15,200	6,920	43,000	5,020	4,010	3,400	1,520	2,000	2,530	3,100
26	23,600	21,100	13,500	6,130	29,400	4,670	5,380	4,330	1,520	5,750	2,530	3,100
27	19,800	25,500	11,000	6,520	22,900	4,670	6,920	8,180	1,750	5,020	2,260	3,100
28	17,400	19,800	10,500	6,520	21,700	4,330	11,000	7,960	1,750	4,330	2,260	2,810
29	15,700	14,600	10,500	5,750	18,600	4,330	11,000	6,520	3,700	4,010	2,260	2,810
30	13,500	....	10,000	6,130	16,300	4,010	9,070	5,380	4,010	3,700	2,260	2,530
31	12,000	....	11,000	....	15,200	....	6,520	4,670	....	4,330	....	2,530
1909												
1	3,090	5,750	14,600	6,130	10,500	6,130	7,330	1,240	1,740	1,440	2,250	1,740
2	3,700	5,020	13,000	6,130	10,000	5,380	6,520	1,480	1,610	1,860	2,120	1,860
3	3,700	4,670	12,000	5,750	9,530	5,380	5,380	1,740	1,480	1,240	1,990	1,740
4	3,390	4,670	11,500	5,750	9,070	10,200	4,670	1,860	1,480	1,120	1,860	1,760
5	3,390	4,330	14,600	5,750	8,620	9,070	4,010	2,120	1,360	1,990	1,610	1,860
6	4,670	4,330	13,000	5,750	8,180	8,620	3,700	2,120	1,480	1,740	1,740	1,740
7	7,330	4,670	12,500	5,380	7,750	19,800	3,390	2,120	1,610	1,610	1,860	1,740
8	6,520	4,670	11,500	5,380	7,330	16,300	3,090	1,990	1,740	1,480	1,740	1,990
9	5,750	5,020	11,000	5,380	6,520	11,500	2,800	1,860	1,610	1,010	1,860	2,250
10	5,020	5,750	11,000	5,020	6,130	10,500	2,520	1,740	1,860	1,610	2,120	2,520
11	4,670	9,530	10,500	5,020	6,130	12,500	2,520	1,990	1,860	1,010	1,990	3,540
12	4,330	15,700	10,500	5,020	7,750	17,400	2,520	1,990	1,740	2,120	1,860	3,090
13	4,010	15,200	10,500	4,670	7,330	15,200	2,520	1,860	1,740	1,860	1,480	2,940
14	4,010	12,500	9,530	8,180	6,920	13,500	2,380	1,740	1,610	2,250	1,610	3,090
15	3,700	10,500	8,620	17,400	6,520	11,000	2,520	1,610	1,610	3,090	1,480	6,720
16	4,010	11,000	8,180	74,300	6,130	13,000	2,520	1,940	2,250	3,390	2,120	6,720
17	3,700	10,500	7,750	33,500	5,380	11,000	1,990	3,090	2,380	3,090	1,860	6,560
18	6,520	11,500	6,920	22,900	5,380	11,000	1,990	2,520	1,990	2,520	1,740	5,750
19	6,130	11,500	6,520	16,300	5,020	19,200	1,990	4,170	1,990	2,380	1,860	4,010
20	5,750	11,000	6,130	13,000	5,380	16,300	1,990	3,540	1,990	2,120	1,740	3,090

Daily discharge, in second-feet, of Potomac River at Point of Rocks, Md., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	5,750	11,000	5,750	12,500	5,380	12,500	1,740	3,090	1,860	1,990	1,860	2,960
22	5,380	11,000	5,380	34,200	5,750	8,180	1,740	2,520	1,990	1,990	1,860	2,790
23	5,750	11,500	5,380	32,100	15,200	6,920	1,740	2,380	1,860	1,860	1,990	2,790
24	9,070	14,100	5,380	31,500	24,800	7,330	1,480	2,250	2,120	1,860	2,120	2,660
25	15,200	31,500	5,020	30,100	16,300	6,520	1,480	2,120	1,990	1,990	1,990	2,530
26	29,400	29,400	5,020	28,800	13,000	5,750	1,480	1,990	1,860	4,010	1,860	2,660
27	15,700	22,300	5,020	26,100	11,000	6,130	1,480	1,860	1,740	5,020	1,610	2,790
28	12,500	17,400	5,380	21,100	9,070	11,500	1,480	1,740	1,740	3,540	1,740	3,460
29	9,070	....	5,750	16,300	8,180	12,000	1,480	1,480	1,610	2,800	1,740	3,330
30	7,750	....	5,750	11,000	7,330	11,500	1,740	1,480	1,480	2,660	1,860	2,790
31	6,520	....	6,130	....	6,920	....	1,480	1,740	....	1,860	....	3,610
1910												
1	2,200	6,920	22,300	3,390	12,000	3,860	6,130	2,520	1,480	1,510	1,480	1,610
2	2,200	6,520	33,500	3,390	10,500	3,700	6,520	2,520	1,480	1,480	1,610	1,480
3	2,200	5,750	32,800	3,540	9,070	3,860	5,380	2,660	1,510	1,480	1,510	1,360
4	2,200	5,380	28,800	3,700	7,750	3,860	5,020	2,800	1,990	1,510	1,480	1,480
5	2,200	5,750	20,400	3,860	6,520	3,700	5,020	3,090	2,940	1,890	1,480	1,610
6	5,000	5,020	17,400	3,700	5,750	4,330	6,520	2,660	2,800	1,480	1,540	2,120
7	6,000	5,380	14,100	3,700	5,380	4,170	6,520	2,520	2,520	1,390	1,410	2,120
8	5,000	6,520	12,500	3,540	5,020	4,010	6,130	2,250	2,380	1,610	1,390	1,860
9	10,000	5,750	11,000	3,540	5,020	4,010	7,330	2,120	2,120	1,640	1,240	1,860
10	3,000	5,380	10,000	3,390	4,840	4,670	6,520	1,990	1,890	1,480	1,510	2,120
11	3,000	5,750	9,070	3,240	4,840	5,380	5,750	1,860	1,790	1,610	1,480	1,990
12	2,500	4,330	7,750	3,090	4,840	15,200	5,750	1,790	1,740	1,760	1,480	1,990
13	2,500	4,500	6,130	3,090	4,670	28,100	6,130	1,760	1,740	1,610	1,360	2,120
14	2,500	4,840	6,130	2,940	4,500	31,500	6,520	1,760	1,760	1,740	1,290	1,990
15	2,500	5,020	5,750	2,800	4,330	26,800	7,330	1,860	1,760	1,610	1,360	1,990
16	2,300	5,750	5,750	2,800	4,170	25,500	6,520	1,990	1,740	1,480	1,390	1,990
17	2,300	10,500	5,750	3,090	4,010	99,600	6,520	2,120	1,740	1,510	1,480	2,120
18	2,300	41,500	5,750	3,860	4,010	155,000	5,750	1,860	1,740	1,390	1,510	1,990
19	3,000	44,500	5,380	15,700	3,860	84,600	5,750	1,760	1,610	1,360	1,290	1,860
20	5,000	32,800	5,020	18,600	3,860	82,200	9,070	1,740	1,360	1,480	1,240	1,990
21	40,000	23,600	4,840	16,800	3,860	58,900	6,130	1,760	1,480	1,480	1,360	3,390
22	84,600	14,600	4,670	14,600	4,500	32,100	5,750	1,790	1,480	1,610	1,360	2,940
23	59,800	38,500	4,500	13,000	4,170	28,800	5,020	1,760	1,360	1,480	1,290	2,380
24	34,200	32,800	4,330	11,500	4,010	19,200	4,170	1,760	1,390	1,360	1,240	2,250
25	18,000	21,100	4,170	13,000	4,500	14,100	3,700	1,740	1,360	1,610	1,480	2,250
26	12,500	14,100	3,860	37,100	5,750	12,000	3,540	1,740	900	2,120	1,860	2,520
27	9,530	12,000	3,700	35,600	8,620	11,000	3,540	1,740	1,480	1,860	1,610	2,250
28	9,070	12,200	3,390	31,500	6,520	8,180	3,540	1,610	1,610	1,740	1,480	2,120
29	9,070	....	3,390	19,200	5,380	7,330	3,700	1,480	1,480	1,610	1,510	2,120
30	9,070	....	3,390	14,600	4,670	6,920	2,660	1,480	1,480	1,480	1,510	2,250
31	8,180	....	3,390	....	4,170	....	2,660	1,510	....	1,510	....	2,520
1911												
1	1,990	59,800	9,530	7,330	7,330	2,660	4,010	1,190	93,800	5,750	4,500	4,670
2	4,500	26,100	10,000	7,330	8,180	2,800	3,090	1,080	67,200	6,520	4,330	4,500
3	8,180	19,800	9,070	6,920	8,180	2,660	2,800	1,080	25,500	5,380	4,010	4,170
4	32,800	19,800	7,750	7,330	8,180	2,600	2,520	1,120	14,100	5,750	3,540	4,330
5	29,400	11,500	6,520	8,180	6,920	2,940	2,250	1,860	13,000	9,070	3,090	4,330
6	23,600	10,500	6,130	35,600	6,520	2,800	2,120	2,660	7,330	6,520	2,940	3,860
7	14,600	9,070	5,750	51,600	5,750	2,660	1,990	2,380	6,130	5,750	4,010	4,010
8	11,500	8,180	5,380	36,300	5,380	2,660	2,800	2,250	5,020	4,010	7,750	3,860
9	7,330	7,330	5,020	23,600	5,020	2,940	4,010	1,740	4,500	5,020	13,000	3,700
10	5,750	6,920	5,020	20,400	4,840	2,660	2,800	1,860	4,010	10,000	11,000	3,540
11	5,380	6,520	6,130	19,800	4,670	4,010	3,240	1,860	5,380	7,330	9,070	3,890
12	4,500	6,130	9,070	18,000	4,500	3,860	2,940	1,610	5,020	6,130	7,330	3,390
13	4,500	6,130	16,900	17,400	4,170	3,540	2,520	1,790	4,500	5,750	6,920	3,890
14	5,020	6,520	17,400	17,400	4,010	3,390	2,520	1,120	3,860	5,750	6,520	3,390
15	20,400	8,180	18,000	16,800	3,860	3,390	2,520	1,480	4,330	5,380	6,520	3,540

Daily discharge, in second-feet, of Potomac River at Point of Rocks, Md., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
16	17,400	10,500	17,400	16,300	3,700	3,890	1,990	1,360	5,380	5,020	5,380	5,020
17	14,100	11,000	16,800	14,100	3,700	3,390	2,800	1,240	23,600	4,500	5,380	7,750
18	10,500	9,070	15,700	12,000	3,540	2,380	2,120	1,360	17,400	7,330	5,380	21,100
19	7,750	8,180	12,500	11,000	3,390	2,940	1,860	1,740	11,500	19,800	5,380	16,300
20	6,520	9,070	11,000	10,500	3,240	3,700	1,610	1,480	8,620	33,500	6,130	10,000
21	5,750	7,330	10,500	10,000	3,090	7,750	1,480	1,240	6,920	20,400	6,520	8,620
22	5,380	7,330	10,000	10,000	2,940	4,840	1,740	1,120	6,130	13,000	6,920	6,520
23	5,020	6,520	9,530	9,530	2,940	4,010	1,610	1,010	5,020	12,000	6,130	4,330
24	5,380	6,520	9,070	10,000	2,850	3,390	1,360	1,120	5,020	10,000	6,130	19,800
25	5,750	6,130	8,180	10,000	2,760	2,940	1,610	1,240	4,670	8,620	5,750	24,800
26	7,750	5,750	7,330	10,500	2,660	4,010	1,290	1,440	4,170	7,750	5,020	21,100
27	7,330	8,180	6,520	10,000	2,570	3,700	1,480	2,520	3,860	6,520	5,750	22,300
28	8,620	9,070	6,520	10,000	2,470	7,330	1,120	2,120	3,540	6,130	5,020	29,400
29	16,300	....	6,920	9,070	2,380	6,320	680	1,740	3,700	5,380	4,840	26,800
30	19,200	....	7,330	7,330	2,250	5,020	1,010	3,860	3,540	5,020	4,840	19,200
31	57,300	....	6,920	....	2,250	....	1,010	26,100	....	4,670	....	16,300
1912												
1	16,800	10,500	25,500	37,100	12,000	6,130	6,920	6,920	1,640	6,920	2,660	2,120
2	21,100	10,000	18,600	30,800	11,500	5,380	6,130	7,750	2,250	6,130	2,660	2,380
3	19,800	10,000	14,600	23,600	11,000	6,130	5,750	7,330	2,940	5,380	2,520	2,120
4	17,400	9,070	12,000	22,300	10,500	5,380	6,920	4,670	3,390	4,500	2,250	2,250
5	13,000	8,180	10,500	19,200	8,180	5,020	4,670	4,330	2,940	3,860	2,250	2,520
6	6,520	8,180	10,000	18,600	7,750	5,380	4,330	3,540	5,020	3,390	2,380	3,090
7	6,130	8,180	9,070	16,800	7,330	5,750	4,500	3,090	2,800	3,860	2,380	3,240
8	5,380	8,180	8,180	13,000	16,800	5,020	4,840	2,940	2,660	3,540	4,330	2,800
9	4,670	7,330	8,180	12,000	17,400	4,330	4,500	3,700	2,520	2,940	5,830	3,700
10	....	6,920	9,070	11,000	14,100	4,500	4,170	3,240	2,660	2,800	7,330	3,860
11	....	7,330	10,000	9,070	11,500	3,860	4,010	2,940	2,380	2,660	6,520	4,010
12	....	7,330	9,070	9,070	17,400	4,170	4,330	3,540	2,250	2,380	6,130	4,170
13	....	7,330	12,000	7,330	46,000	4,500	4,670	3,700	2,120	2,120	4,330	3,240
14	....	6,520	16,300	7,330	68,900	3,700	3,860	4,010	2,380	3,240	3,860	2,800
15	....	6,920	25,500	9,070	37,100	4,170	4,840	3,700	1,890	2,520	3,700	2,380
16	....	7,750	72,200	9,070	28,100	7,330	4,010	2,940	1,990	2,380	3,240	3,240
17	....	7,750	80,500	8,620	47,600	6,130	3,860	2,800	1,760	2,520	3,240	3,540
18	....	7,330	45,300	13,000	64,700	6,520	8,180	2,940	1,890	2,120	3,240	3,390
19	....	8,620	29,400	18,000	32,800	6,130	6,520	2,660	1,990	2,380	3,090	3,700
20	....	9,070	24,800	26,100	28,100	6,130	6,130	2,800	1,990	2,520	2,800	3,540
21	....	10,000	24,200	18,600	19,800	5,020	9,070	2,660	1,890	2,660	2,520	3,390
22	....	14,100	58,900	16,300	14,100	4,500	10,000	2,800	2,120	2,380	2,380	2,940
23	....	18,000	50,000	14,100	13,000	4,500	11,500	2,660	2,120	2,520	2,380	3,240
24	....	20,000	33,500	12,000	11,500	5,020	12,000	2,520	9,530	2,520	2,250	3,390
25	....	24,000	39,200	11,000	10,500	5,750	9,070	2,520	35,600	2,380	2,380	3,240
26	....	26,000	40,000	10,000	9,070	5,750	46,000	2,520	39,200	2,120	2,520	3,540
27	....	77,200	31,500	10,000	8,620	5,380	24,200	2,520	20,400	2,520	2,120	3,540
28	....	80,500	25,500	10,500	7,330	5,380	14,600	2,520	11,500	2,800	2,380	3,700
29	....	44,500	28,100	11,000	6,920	6,130	9,530	2,520	10,500	2,660	2,250	3,860
30	11,000	....	53,200	11,500	6,520	5,380	8,620	2,120	8,620	2,520	2,120	4,010
31	11,000	....	54,800	....	6,130	....	7,330	2,250	....	2,660	....	8,180
1913												
1	13,000	8,180	3,240	21,100	6,920	50,800	8,180	3,540	1,610	2,380	6,920	5,750
2	16,300	7,750	3,090	17,400	6,130	26,100	6,920	3,860	1,340	3,270	5,380	4,840
3	28,800	8,180	3,390	14,600	5,750	20,400	4,330	4,500	1,790	4,160	5,380	5,020
4	13,500	7,330	4,010	13,000	5,750	15,200	4,010	5,020	1,460	3,240	4,840	5,020
5	13,500	7,330	3,860	13,000	5,750	23,600	4,170	4,500	1,390	2,520	4,010	5,380
6	13,000	7,330	3,700	12,000	5,750	19,200	4,670	4,500	1,440	3,090	3,700	5,020
7	12,000	6,920	3,540	9,070	5,380	14,100	5,020	4,330	1,460	2,250	3,540	6,920
8	13,500	6,520	3,540	9,070	5,020	10,000	4,670	3,860	1,340	2,120	3,240	10,000
9	24,200	6,920	3,540	8,180	5,020	10,500	4,840	3,700	1,710	2,120	4,170	14,600
10	21,700	7,330	3,700	8,180	4,330	8,620	3,700	3,240	1,340	2,250	46,800	13,000

Daily discharge, in second-feet, of Potomac River at Point of Rocks, Md., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	16,300	6,520	3,540	8,180	4,500	9,530	3,390	2,940	1,080	2,120	53,200	9,580
12	16,300	6,920	3,390	7,750	4,010	8,620	8,620	3,240	1,150	1,580	25,500	7,750
13	14,100	6,130	5,020	10,500	3,860	8,180	6,920	2,800	1,310	4,840	16,300	7,330
14	13,500	6,130	9,530	19,800	3,700	7,330	6,130	2,520	1,340	4,330	10,000	6,920
15	11,000	6,130	19,200	26,800	4,170	6,130	4,670	2,660	748	3,700	10,500	6,520
16	9,070	5,750	28,800	31,500	3,700	5,020	4,010	2,660	1,440	3,090	16,800	5,750
17	8,620	5,380	32,100	62,200	4,500	5,020	3,540	1,990	1,100	2,940	27,500	5,750
18	8,180	5,020	21,100	40,700	5,020	7,750	4,670	3,090	1,440	3,090	27,500	4,840
19	9,070	4,840	16,300	23,600	6,130	5,750	5,020	3,700	1,340	1,810	22,300	4,670
20	8,620	4,840	13,000	20,400	6,520	3,390	4,670	2,520	1,710	2,660	23,600	4,330
21	7,330	4,670	10,500	16,890	6,130	2,660	4,330	2,380	1,810	3,390	16,300	4,170
22	6,920	4,500	10,000	14,100	6,130	3,240	4,010	2,120	2,520	6,920	11,000	4,670
23	6,520	4,500	8,180	12,000	5,750	3,700	3,540	2,940	2,800	8,620	8,180	5,020
24	6,520	4,500	8,180	10,000	9,070	3,540	3,390	2,520	2,940	7,750	6,520	5,020
25	6,130	4,500	5,750	9,070	49,200	2,940	3,540	2,250	3,860	7,330	11,500	4,840
26	6,920	3,860	6,520	8,620	32,100	5,380	3,090	2,120	3,240	16,800	7,330	5,380
27	7,330	3,540	24,800	9,070	21,100	7,750	3,240	2,250	2,520	43,000	6,130	24,200
28	7,750	3,390	118,000	9,070	59,800	3,540	3,090	2,250	1,940	25,500	5,750	19,200
29	8,180	....	105,000	9,070	66,400	6,130	2,940	2,120	1,940	16,300	5,380	16,300
30	7,330	....	51,600	8,180	37,800	9,070	2,800	1,680	1,960	11,000	5,380	13,000
31	7,330	....	28,100	....	26,100	....	2,940	1,640	....	8,180	....	11,000
1914												
1	9,070	28,800	9,070	18,600	19,200	4,670	3,700	1,460	2,660	1,410	834	1,100
2	10,000	39,200	8,620	17,400	16,800	4,500	3,390	1,660	2,120	1,010	1,080	1,220
3	10,500	30,800	8,620	16,800	14,100	3,390	3,090	2,380	2,120	922	1,150	1,510
4	33,500	22,300	5,750	16,300	12,500	3,090	3,240	2,660	1,990	834	1,100	1,740
5	45,300	18,600	10,500	16,300	11,000	2,940	2,800	1,790	1,940	706	1,260	1,340
6	30,800	15,200	9,530	15,200	15,700	2,800	2,940	1,120	1,760	1,100	1,510	2,380
7	23,600	19,200	8,620	14,600	22,900	2,940	3,240	1,010	1,460	1,150	1,100	3,540
8	19,200	18,600	10,000	14,100	19,200	2,800	3,240	769	1,240	706	1,120	13,000
9	18,600	18,000	10,000	15,200	9,530	2,940	3,240	1,390	769	1,220	1,510	15,700
10	16,300	17,400	10,000	15,700	17,400	3,390	3,090	1,660	540	1,390	1,220	13,000
11	21,900	14,600	9,530	17,400	14,100	3,240	2,940	1,940	622	1,170	878	12,000
12	27,500	13,500	10,000	13,000	13,500	2,940	2,380	1,810	1,220	966	769	11,500
13	24,200	8,620	10,000	12,000	12,000	2,660	2,940	1,660	1,100	922	685	12,000
14	23,600	6,920	10,500	10,500	10,500	2,380	2,520	1,580	1,010	966	643	8,620
15	14,600	5,750	12,000	9,070	9,070	2,380	2,380	1,480	922	878	727	8,180
16	12,000	6,130	11,000	14,600	7,750	2,380	2,120	1,560	1,260	727	966	3,700
17	11,500	6,920	48,400	41,500	7,330	2,120	5,750	1,440	1,120	1,150	1,220	3,540
18	11,500	6,920	60,600	33,500	7,330	2,520	7,750	1,100	1,100	2,250	2,080	3,140
19	10,000	6,520	67,200	27,500	6,520	2,660	4,330	1,790	922	2,380	2,940	3,540
20	9,530	9,070	43,700	20,400	5,750	2,660	4,010	1,390	988	2,800	2,660	3,540
21	8,180	21,100	31,500	19,200	5,020	2,940	3,700	1,440	1,080	2,120	2,380	4,010
22	10,000	26,800	22,300	18,000	5,020	3,090	3,090	1,610	1,220	1,990	2,520	4,830
23	28,800	20,400	20,400	22,900	4,670	3,390	2,250	1,260	944	1,940	2,660	4,500
24	21,100	15,700	18,600	19,800	4,670	3,540	1,940	1,460	1,260	1,790	2,800	6,520
25	22,300	13,500	16,300	15,200	4,840	3,540	2,520	1,640	1,390	1,460	2,120	8,620
26	27,200	11,500	15,700	22,900	4,010	2,660	2,800	2,380	1,170	1,260	1,910	9,070
27	32,100	12,000	17,400	41,500	3,090	4,670	2,250	2,120	1,080	1,910	1,710	5,380
28	24,200	11,500	16,300	52,400	3,700	3,700	1,890	1,940	944	1,960	1,660	5,750
29	20,400	....	21,200	30,800	3,390	4,010	1,260	2,380	856	1,940	1,560	4,330
30	19,800	....	26,100	25,500	3,700	4,840	966	3,090	1,150	1,760	1,460	4,670
31	21,700	....	20,400	....	3,390	....	1,810	3,390	....	727	....	4,500

NOTE.—Discharge, except for periods during which discharge relation was affected by ice, determined from a rating curve well defined except at extreme low stages. Estimate of discharge Dec. 22-31, 1909, reduced 10 per cent because of effect of ice. Discharge Jan. 1-20, 1910, and Feb. 23-26, 1912, estimated, because of ice, from climatologic records.

Monthly discharge of Potomac River at Point of Rocks, Md., 1895–1914.

[Drainage area, 9,650 square miles.[a]]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1895						
January	....	....	....	....	....	
February 17-28	15,260	5,320	7,413	0.768	0.343	
March	65,980	11,520	24,560	2.54	2.93	
April	67,640	6,200	14,500	1.50	1.67	
May	29,340	7,120	12,540	1.30	1.50	
June	7,580	2,280	4,033	.418	.466	
July	10,500	2,600	4,443	.460	.530	
August	3,300	1,340	1,997	.207	.239	
September	2,600	1,180	1,565	.162	.181	
October	1,340	1,040	1,163	.120	.138	
November	1,540	1,180	1,333	.138	.154	
December	5,320	1,180	2,259	.234	.270	
1896						
January	24,100	1,180	5,257	.545	.628	
February	37,080	2,600	10,470	1.08	1.16	
March	....	....	....	....	....	
April	....	....	....	....	....	
May 11-31	5,320	1,540	2,560	.265	.207	
June	14,160	1,180	5,429	.562	.627	
July	50,300	2,940	9,283	.962	1.11	
August	9,500	1,540	3,449	.357	.412	
September	25,380	1,180	2,175	.225	.251	
October	159,400	2,000	12,490	1.29	1.49	
November	30,020	2,000	6,928	.718	.801	
December	12,040	2,000	4,723	.489	.564	
1897						
January	8,540	2,280	4,284	.444	.512	
February	182,200	6,660	42,660	4.42	4.60	
March	31,380	11,520	20,850	2.16	2.49	
April	28,000	5,760	10,830	1.12	1.25	
May	94,200	5,760	22,950	2.38	2.74	
June	7,580	4,080	5,997	.621	.693	
July	10,500	2,940	5,315	.551	.635	
August	6,200	3,300	4,092	.424	.489	
September	2,940	2,000	2,337	.242	.270	
October	2,600	1,760	1,968	.204	.235	
November	4,480	1,340	2,096	.217	.242	
December	19,260	2,600	6,579	.681	.785	
The year	182,200	1,340	10,830	1.12	14.94	
1898						
January	41,600	3,300	14,660	1.52	1.75	
February	18,100	5,760	8,339	.864	.900	
March	65,150	4,480	15,470	1.60	1.84	
April	52,700	9,020	15,970	1.65	1.84	
May	69,720	6,200	18,060	1.87	2.16	
June	8,060	2,600	4,178	.433	.483	
July	5,760	1,540	2,418	.250	.288	
August	111,400	3,680	22,140	2.29	2.64	
September	3,680	2,000	2,497	.259	.289	
October	86,730	1,760	13,580	1.41	1.63	
November	15,260	5,320	8,557	.886	.988	
December	54,360	6,200	15,330	1.59	1.83	
The year	111,400	1,540	11,780	1.22	16.64	

[a] 9,654 square miles used previous to 1906.

Monthly discharge of Potomac River at Point of Rocks, Md., 1895–1914—Continued.

Month	Discharge in second-feet: Maximum	Minimum	Mean	Per square mile	Run-off (depth in inches on drainage area)	Accuracy
1899						
January	45,500	8,540	20,870	2.16	2.49	
February	100,800	7,120	28,130	2.91	3.03	
March	115,400	14,160	35,240	3.65	4.21	
April	25,380	5,760	11,750	1.22	1.36	
May	49,140	5,320	11,600	1.20	1.38	
June	16,380	2,940	5,314	.550	.614	
July	7,120	1,540	2,519	.261	.301	
August	3,680	1,540	2,335	.242	.279	
September	3,680	1,760	2,345	.243	.271	
October	2,000	1,540	1,663	.172	.198	
November	9,500	2,000	3,171	.328	.366	
December	12,040	2,000	4,068	.421	.485	
The year	115,400	1,540	10,750	1.11	14.98	
1900						
January	35,620	3,680	8,166	.846	.975	
February	37,820	2,940	13,340	1.38	1.44	
March	50,300	8,540	18,470	1.91	2.20	
April	22,240	5,320	9,295	.963	1.07	
May	7,120	2,940	4,466	.463	.534	
June	48,700	2,600	8,394	.869	.970	
July	7,120	1,340	3,008	.312	.360	
August	3,680	1,340	1,917	.199	.229	
September	2,000	1,040	1,344	.139	.155	
October	2,600	1,180	1,333	.138	.159	
November	46,300	1,040	4,570	.473	.528	
December	29,340	2,280	6,218	.644	.742	
The year	50,300	1,040	6,710	.695	9.36	
1901						
January	21,040	1,760	4,929	.511	.589	
February	6,200	2,280	3,649	.378	.394	
March	80,920	2,280	13,800	1.43	1.65	
April	150,600	7,120	39,750	4.12	4.60	
May	95,860	6,200	26,920	2.79	3.22	
June	48,700	8,060	18,840	1.95	2.18	
July	26,680	4,900	10,720	1.11	1.28	
August	20,440	4,080	8,337	.864	.996	
September	28,000	3,680	7,636	.791	.882	
October	12,040	2,600	4,303	.446	.514	
November	19,840	2,280	4,648	.481	.537	
December	130,700	4,480	25,610	2.65	3.06	
The year	150,600	1,760	14,100	1.46	19.90	
1902						
January	75,110	7,580	17,520	1.81	2.09	
February	203,800	9,020	32,520	3.37	3.51	
March	218,700	14,700	54,410	5.64	6.50	
April	108,700	7,750	28,760	2.99	3.34	
May	9,530	4,670	5,973	.619	.714	
June	4,330	2,530	3,186	.330	.368	
July	4,330	2,000	3,086	.320	.369	
August	4,330	1,515	2,464	.255	.294	
September	2,000	1,295	1,490	.154	.172	
October	5,380	1,515	2,767	.287	.331	
November	11,470	1,750	2,837	.294	.328	
December	54,780	7,330	18,970	1.96	2.26	
The year	218,700	1,295	14,500	1.50	20.28	

Monthly discharge of Potomac River at Point of Rocks, Md., 1895–1914—Continued.

Month	Discharge in second-feet: Maximum	Minimum	Mean	Per square mile	Run-off (depth in inches on drainage area)	Accuracy
1903						
January	68,880	6,520	17,200	1.78	2.05	
February	49,100	12,490	22,190	2.30	2.40	
March	99,590	9,070	26,730	2.77	3.19	
April	97,930	9,530	28,900	2.99	3.34	
May	9,070	4,330	6,212	.643	.741	
June	73,860	6,520	17,970	1.86	2.08	
July	45,260	4,330	12,760	1.32	1.52	
August	8,620	2,810	4,826	.500	.576	
September	16,850	2,530	4,669	.484	.540	
October	6,130	2,000	3,212	.333	.384	
November	2,810	2,000	2,175	.225	.251	
December	4,010	2,000	2,926	.303	.349	
The year	99,590	2,000	12,480	1.29	17.42	
1904						
January	35,620	3,400	7,287	.755	.870	
February	37,060	8,620	17,480	1.81	1.95	
March	22,300	5,380	11,170	1.16	1.34	
April	28,120	3,400	7,406	.767	.856	
May	27,460	5,380	9,362	.970	1.12	
June	38,500	3,100	10,160	1.05	1.17	
July	10,970	2,530	4,510	.467	.538	
August	3,400	1,750	2,394	.248	.286	
September	2,000	1,295	1,592	.165	.184	
October	2,000	900	1,164	.121	.140	
November	1,515	1,090	1,340	.139	.155	
December	5,020	1,515	2,201	.228	.263	
The year	38,500	900	6,339	.657	8.87	
1905						
January	17,430	4,670	8,626	.894	1.03	
February	6,520	5,020	5,625	.583	.607	
March	63,900	6,520	23,480	2.43	2.80	
April	10,000	4,010	6,581	.682	.761	
May	9,070	2,810	4,493	.465	.536	
June	32,820	2,810	6,579	.681	.760	
July	22,300	3,400	10,190	1.06	1.22	
August	13,530	2,810	5,830	.604	.696	
September	5,750	2,000	3,205	.332	.370	
October	5,380	1,750	2,888	.299	.345	
November	3,700	1,750	2,267	.235	.262	
December	37,060	3,400	10,640	1.10	1.27	
The year	63,900	1,750	7,534	.780	10.66	
1906						
January	44,500	8,180	15,000	1.55	1.79	
February	9,070	3,700	5,120	.530	.55	
March	79,700	4,330	15,900	1.65	1.90	
April	64,700	8,180	22,400	2.33	2.60	
May	10,500	2,810	5,540	.574	.66	
June	19,800	3,400	7,010	.726	.81	
July	8,620	2,530	4,380	.454	.52	
August	37,100	3,400	15,200	1.58	1.82	
September	12,500	2,330	4,280	.444	.50	
October	106,000	2,530	16,300	1.69	1.95	
November	15,200	4,010	6,340	.657	.73	
December	55,600	4,010	11,000	1.14	1.31	
The year	106,000	2,330	10,700	1.11	15.14	

Monthly discharge of Potomac River at Point of Rocks, Md., 1895–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1907						
January	72,200	9,530	27,000	2.80	3.23	A.
February	13,500	7,330	9,560	.991	1.03	A.
March	114,000	9,530	30,500	3.16	3.64	A.
April	51,600	6,920	14,900	1.54	1.72	A.
May	37,800	6,920	11,100	1.15	1.33	A.
June	93,800	7,330	23,200	2.40	2.68	A.
July	11,000	4,330	6,010	.623	.72	A.
August	5,020	3,100	3,710	.384	.44	A.
September	26,800	2,810	6,430	.666	.74	A.
October	6,130	2,260	3,550	.368	.42	A.
November	26,500	2,530	7,850	.813	.91	A.
December	69,700	5,380	17,800	1.84	2.12	A.
The year	114,000	2,260	13,500	1.39	18.98	
1908						
January	136,000	6,920	25,400	2.63	3.03	A.
February	129,000	6,920	24,100	2.50	2.70	A.
March	67,200	10,000	28,600	2.96	3.41	A.
April	16,800	5,750	10,200	1.06	1.18	A.
May	97,100	6,130	32,100	3.33	3.84	A.
June	15,200	4,010	7,250	.751	.84	A.
July	11,000	2,530	4,470	.463	.53	A.
August	8,180	2,530	3,880	.402	.46	A.
September	4,010	1,520	2,500	.259	.29	A.
October	5,750	1,750	2,780	.288	.33	A.
November	4,670	2,000	2,670	.277	.31	A.
December	3,400	1,520	2,440	.253	.29	A.
The year	136,000	1,520	12,200	1.26	17.21	
1909						
January	29,400	3,090	6,950	0.720	0.83	A.
February	31,500	4,330	11,300	1.17	1.22	A.
March	14,600	5,020	8,700	.902	1.04	A.
April	74,300	4,670	16,700	1.73	1.93	A.
May	24,800	5,020	8,660	.897	1.03	A.
June	19,800	5,380	11,000	1.14	1.27	A.
July	7,330	1,480	2,700	.280	.32	A.
August	4,170	1,240	2,110	.219	.25	A.
September	2,380	1,360	1,780	.184	.21	A.
October	5,020	1,010	2,190	.227	.26	A.
November	2,250	1,480	1,850	.192	.21	A.
December	6,720	1,740	3,130	.324	.37	B.
The year	74,300	1,010	6,370	.658	8.94	
1910						
January	84,600	2,200	11,700	1.21	1.40	B.
February	44,500	4,330	12,200	1.26	1.31	B.
March	33,500	3,390	9,960	1.03	1.19	A.
April	37,100	2,800	10,100	1.05	1.17	A.
May	12,000	3,860	5,520	.572	.66	A.
June	155,000	3,700	26,400	2.74	3.06	A.
July	9,070	2,660	5,500	.570	.66	A.
August	3,090	1,480	2,000	.207	.24	A.
September	2,940	900	1,740	.180	.20	A.
October	2,120	1,360	1,560	.162	.19	A.
November	1,860	1,240	1,440	.149	.17	A.
December	3,390	1,360	2,090	.217	.25	B.
The year	155,000	900	7,450	.772	10.50	

Monthly discharge of Potomac River at Point of Rocks, Md., 1895–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1911						
January	57,300	1,990	12,200	1.26	1.45	A.
February	59,800	5,750	11,300	1.17	1.22	A.
March	18,000	5,020	9,670	1.00	1.15	A.
April	51,600	6,920	15,100	1.56	1.74	A.
May	8,180	2,250	4,330	.449	.52	A.
June	7,750	2,380	3,690	.382	.43	A.
July	4,010	680	2,160	.224	.26	A.
August	26,100	1,010	2,440	.253	.29	A.
September	93,800	3,540	12,600	1.31	1.46	A.
October	33,500	4,010	8,510	.882	1.02	A.
November	13,000	2,940	5,970	.619	.69	A.
December	29,400	3,390	10,200	1.06	1.22	A.
The year	93,800	680	8,150	.845	11.45	
1912						
January	21,100	4,670	9,450	0.979	1.13	D.
February	80,500	6,520	16,400	1.70	1.83	C.
March	80,500	8,180	28,700	2.97	3.42	A.
April	37,100	7,330	14,900	1.54	1.72	A.
May	68,900	6,130	19,800	2.05	2.36	A.
June	7,330	3,700	5,280	.547	.61	A.
July	46,000	3,860	8,550	.886	1.02	A.
August	7,750	2,120	3,460	.359	.41	A.
September	39,200	1,640	6,360	.659	.74	A.
October	6,920	2,120	3,090	.320	.37	A.
November	7,330	2,120	3,270	.339	.38	A.
December	8,180	2,120	3,390	.351	.40	A.
The year	80,500	1,640	10,200	1.06	14.39	
1913						
January	28,800	6,130	11,700	1.21	1.40	A.
February	8,180	3,390	5,890	.610	.64	A.
March	118,000	3,090	18,200	1.89	2.18	A.
April	62,200	7,750	16,100	1.67	1.86	A.
May	66,400	3,700	13,600	1.41	1.63	A.
June	50,800	2,660	10,400	1.08	1.20	A.
July	8,620	2,800	4,490	.465	.54	A.
August	5,020	1,640	3,010	.312	.36	A.
September	3,860	748	1,770	.183	.20	B.
October	43,000	1,580	6,880	.713	.82	A.
November	53,200	3,240	13,500	1.40	1.56	A.
December	24,200	4,170	8,120	.841	.97	A.
The year	118,000	748	9,490	.983	13.36	
1914						
January	45,300	8,180	20,000	2.07	2.39	A.
February	39,200	5,750	15,900	1.65	1.72	A.
March	67,200	5,750	19,300	2.00	2.31	A.
April	52,400	9,070	20,900	2.17	2.42	A.
May	22,900	3,090	9,600	.995	1.15	A.
June	4,840	2,120	3,190	.330	.37	A.
July	7,750	966	3,020	.313	.36	A.
August	3,390	769	1,750	.181	.21	A.
September	2,060	540	1,270	.132	.15	B.
October	2,800	706	1,400	.145	.17	B.
November	2,940	643	1,540	.160	.18	B.
December	15,700	1,100	6,000	.622	.72	A.
The year	67,200	540	8,650	.896	12.15	

NOTE.—Estimates for Jan. 1 to June 17, 1896, the year 1897, and Apr. 16, 1901, to Sept. 1, 1902, subject to error because of uncertainties in gage readings and gage datum. Ice was present in the stream Feb. 11-23, 1902; Dec. 17-23; during parts of January and February, 1904; Jan. 27, 1905, and possibly at other periods previous to 1906. No corrections have been made in the estimates previous to 1906 for effect of ice. Mean discharge Jan. 10-29, 1912, estimated 8,000 second-feet because of ice.

SOUTH RIVER AT BASIC CITY, VA.

Location.—At the highway bridge half a mile below the Chesapeake & Ohio Railway bridge at Basic City, and about half a mile northeast of Waynesboro.

Drainage area.—142 square miles.

Records available.—June 29, 1905, to July 15, 1906.

Gage.—Chain on upstream handrail of bridge; read once daily.

Discharge measurements.—Made from the bridge.

Channel and control.—Both banks subject to overflow, the right bank only during very high water. Current sluggish at ordinary stages. Bed of stream composed of rocks and mud; probably changes during floods.

Extremes of discharge.—Maximum stage recorded: 5.5 feet at 1.30 p. m., December 21, 1905; discharge, 972 second-feet. Minimum stage recorded: 2.0 feet at 1.30 p. m., November 28, 1905; discharge, 7 second-feet.

Winter flow.—River occasionally frozen over for brief periods; discharge relation probably not affected by ice during the period of record.

Regulation.—Operation of flour mills above station causes rapid fluctuation in gage heights at times.

Accuracy.—Results for normal conditions of flow probably reliable except for extreme low stages.

Discharge measurements of South River at Basic City, Va., in 1906.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
April 11	Robert Follansbee	3.25	221
June 14	Follansbee and Padgett	2.69	86

Daily gage height, in feet, of South River at Basic City, Va., for 1906.

[F. J. Bates, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	3.0	3.4	2.8	3.6	2.9	2.75	2.6
2	2.9	3.3	2.8	3.6	2.9	2.7	2.6
3	3.2	3.2	5.3	3.5	2.8	2.6	2.6
4	4.4	3.2	4.9	3.4	2.9	2.6	2.7
5	3.7	3.2	4.0	3.2	2.9	2.5	2.6
6	3.4	3.1	3.8	3.3	2.8	2.4	2.65
7	3.2	3.1	3.5	3.2	3.0	2.6	2.45
8	3.0	3.0	3.5	3.1	3.0	2.6	2.55
9	2.9	2.9	3.3	3.1	2.8	2.5	2.65
10	2.8	2.9	3.0	3.2	2.85	2.5	2.6
11	2.7	2.9	3.1	3.25	2.85	2.4	2.3
12	2.8	2.9	3.1	3.2	2.7	2.5	2.4
13	3.1	2.9	3.1	3.15	2.8	2.6	2.55
14	3.1	2.9	3.0	3.1	2.8	2.7	2.35
15	3.1	2.9	3.1	4.5	2.7	2.6	2.4
16	3.0	2.8	3.2	4.1	2.75	2.6	....
17	3.0	2.7	3.3	3.75	2.8	3.2	....
18	3.1	2.7	3.3	3.55	2.65	2.5	....
19	3.2	2.7	3.3	3.4	2.7	2.8	....
20	3.2	2.7	3.2	3.25	2.7	5.45	....
21	3.1	2.7	3.3	3.25	2.6	4.9	....
22	3.1	2.8	3.2	3.2	2.6	3.45	....
23	4.9	2.8	3.2	3.2	2.6	3.2	....
24	4.4	2.8	3.2	3.1	2.5	3.0	....
25	3.9	2.8	3.1	3.0	2.6	2.9	....
26	3.6	2.8	3.2	3.1	2.6	3.2	....
27	3.6	2.8	3.5	3.05	2.65	2.95	....
28	3.7	2.8	3.7	3.0	2.75	2.85	....
29	3.7	....	3.7	3.0	3.0	2.8	....
30	3.6	....	3.5	2.9	2.7	2.7	....
31	3.5	....	3.8	....	2.75	....	....

NOTE.—Discharge relation probably unaffected by ice.

Daily discharge, in second-feet, of South River at Basic City, Va., for 1905–6.

Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905							
1	....	72	72	55	41	29	19
2	....	55	91	55	29	12	29
3	....	91	55	55	55	19	41
4	....	72	55	55	29	12	135
5	....	63	55	72	19	19	135
6	....	72	55	29	19	29	112
7	....	159	55	19	41	29	72
8	....	112	55	29	41	29	55
9	....	91	55	41	55	29	55
10	....	159	72	55	41	29	55
11	....	91	72	55	55	12	55
12	....	520	72	55	91	29	72
13	....	537	72	19	29	41	29
14	....	786	91	19	19	29	41
15	....	289	91	19	41	19	29

Daily discharge, in second-feet, of South River at Basic City, Va., for 1905–6—Contd.

Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905							
16	....	208	135	19	41	12	29
17	....	159	112	72	19	41	55
18	....	135	91	208	72	19	55
19	....	135	91	112	72	29	55
20	....	112	91	91	41	29	55
21	....	112	72	91	29	12	972
22	....	91	72	72	41	29	470
23	....	41	55	41	55	29	407
24	....	55	55	55	41	29	347
25	....	135	55	72	12	12	261
26	....	112	112	55	41	29	208
27	....	112	72	72	55	12	183
28	....	91	55	72	29	7	135
29	55	112	55	41	41	19	347
30	55	91	29	41	41	29	234
31	....	72	29	....	72	....	208

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	159	261	112	318	135	101	72
2	135	234	112	318	135	91	72
3	208	208	897	289	112	72	72
4	572	208	750	261	135	72	91
5	347	208	438	208	135	55	72
6	261	183	377	234	112	41	82
7	208	183	289	208	159	72	48
8	159	159	289	183	159	72	64
9	135	135	234	183	112	55	82
10	112	135	159	208	123	55	72
11	91	135	183	221	123	41	29
12	112	135	183	208	91	55	41
13	183	135	183	195	112	72	64
14	183	135	159	183	112	91	35
15	183	135	183	607	91	72	41
16	159	112	208	470	101	72	....
17	159	91	234	362	112	208	....
18	183	91	234	304	81	55	....
19	208	91	234	261	91	112	....
20	208	91	208	221	91	953	....
21	183	91	234	221	72	750	....
22	183	112	208	208	72	275	....
23	750	112	208	208	72	208	....
24	572	112	208	183	55	159	....
25	407	112	183	159	72	135	....
26	318	112	208	183	72	208	....
27	318	112	289	171	81	147	....
28	347	112	347	159	101	123	....
29	347	....	347	159	159	112	....
30	318	....	289	135	91	91	....
31	289	....	377	....	101	....	....

NOTE.—Discharge determined from a rating curve fairly well defined between 55 and 470 second-feet.

Monthly discharge of South River at Basic City, Va., for 1905–6.

[Drainage area, 142 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1905					
July	786	41	159	1.12	1.29
August	135	29	70.9	.499	.58
September	208	19	58.2	.410	.46
October	91	12	42.2	.297	.34
November	41	7	23.4	.165	.18
December	972	19	160	1.13	1.30
1906					
January	750	91	258	1.82	2.10
February	261	91	141	.993	1.03
March	897	112	276	1.94	2.24
April	607	135	241	1.70	1.90
May	159	55	106	.746	.86
June	953	41	154	1.08	1.20
July 1-15	91	29	62.5	.440	.24

NOTE.—Results rated as follows: July, August, and December, 1905, and all of 1906, excellent; September, 1905, good; October, 1905, fair; November, 1905, approximate; discharge below 25 second-feet, approximate.

SOUTH FORK OF SHENANDOAH RIVER NEAR FRONT ROYAL, VA.

Location.—About a mile above the highway bridge which is near the Norfolk & Western Railway station, and about 3 miles southwest of Front Royal.

Drainage area.—1,570 square miles.

Records available.—June 26, 1899, to July 7, 1906.

Gage.—Vertical staff spiked to sycamore tree on left bank; high-water staff spiked to a sycamore tree 325 feet upstream; gage read twice daily.

Discharge measurements.—Made from a cable about 800 feet downstream from the low-water gage.

Channel and control.—Left bank overflows; right bank only at extreme stages. Current sluggish. Bed uneven; composed of rock and silt; liable to shift.

Extremes of discharge.—Maximum stage recorded: 23.5 feet, March 1, 1902; discharge, 76,800 second-feet. Minimum stage recorded: 3.4 feet, several times September to December, 1904; discharge, 320 second-feet. A lower discharge, 305 second-feet, is recorded for September 21, 1902, gage height, 3.8 feet. There was a change in rating curves between 1902 and 1904.

Winter flow.—Ice forms at the station and probably affects the discharge relation. No corrections have been applied to computed discharges, however.

Accuracy.—Results probably reliable except for high stages for which they may be 15 to 20 per cent in error.

Discharge measurements of South Fork of Shenandoah River near Front Royal, Va., in 1906 and 1908.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
1906			
June 16	Robert Follansbee	4.70	1,070
1908			
January 15	Follansbee and LaRue	9.2	9,080

Daily gage height, in feet, of South Fork of Shenandoah River near Front Royal, Va., for 1906.

[Miss Brentie Johnson, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	5.65	5.43	4.2	7.05	5.22	4.7	5.45
2	5.45	5.3	4.17	6.8	5.1	4.62	5.28
3	5.25	5.2	4.23	6.45	5.0	4.5	5.25
4	6.13	5.1	5.06	6.25	4.96	4.42	5.25
5	8.47	4.85	7.02	5.85	4.9	4.38	4.9
6	7.22	4.82	6.33	5.68	4.85	4.3	4.45
7	6.4	4.9	5.8	5.52	4.88	4.22	4.65
8	6.0	4.78	5.47	5.4	5.0	4.2	4.62
9	5.65	4.65	5.15	5.32	5.1	4.18	4.4
10	5.88	4.5	5.15	5.3	5.05	4.1	4.28
11	5.17	4.52	5.05	5.4	5.0	4.1	4.3
12	5.0	4.45	4.9	5.35	4.9	4.15	4.38
13	5.0	4.4	4.83	5.28	4.8	4.22	5.32
14	5.0	4.4	4.7	5.2	4.78	4.2	4.65
15	5.06	4.43	4.8	6.35	4.6	4.4	4.4
16	5.3	4.32	5.25	7.75	4.62	4.65	4.25
17	5.3	4.4	5.95	6.8	4.52	5.45	....
18	5.3	4.33	5.77	6.38	4.55	5.75	....
19	5.2	4.3	5.8	6.08	4.45	5.35	....
20	5.12	4.3	5.75	5.8	4.4	5.35	....
21	5.0	4.3	5.8	5.55	4.35	6.2	....
22	4.9	4.25	6.1	5.45	4.3	6.9	....
23	4.93	4.22	5.9	5.35	4.28	6.05	....
24	6.8	4.28	5.8	5.25	4.2	5.5	....
25	6.85	4.25	5.6	5.05	4.2	5.35	....
26	6.22	4.25	5.58	5.1	4.2	5.28	....
27	5.75	4.12	5.77	5.35	4.22	5.72	....
28	5.63	4.25	6.75	5.45	4.3	6.15	....
29	5.6	....	7.35	5.4	4.65	5.5	....
30	5.55	....	7.1	5.3	4.4	5.35	....
31	5.55	....	6.9	....	4.72	....	....

NOTE.—Discharge relation probably unaffected by ice.

Daily discharge, in second-feet, of South Fork of Shenandoah River near Front Royal, Va., for 1906.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	2,140	1,849	670	4,395	1,594	1,060	1,875
2	1,875	1,690	652	3,940	1,460	988	1,666
3	1,630	1,570	691	3,345	1,350	890	1,630
4	2,835	1,460	1,405	3,020	1,300	826	1,630
5	7,354	1,200	4,338	2,420	1,250	796	1,250
6	4,720	1,170	3,148	2,182	1,200	740	850
7	3,260	1,250	2,350	1,966	1,230	684	1,015
8	2,640	1,087	1,901	1,810	1,350	670	988
9	2,140	1,015	1,515	1,714	1,460	658	810
10	1,786	890	1,515	1,690	1,405	610	726
11	1,537	906	1,405	1,810	1,350	610	740
12	1,350	850	1,250	1,750	1,250	640	796
13	1,350	810	1,180	1,666	1,150	684	1,714
14	1,350	810	1,060	1,570	1,182	670	1,015
15	1,405	834	1,150	3,180	970	810	810

Daily discharge, in second-feet, of South Fork of Shenandoah River near Front Royal, Va., for 1906—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
16	1,690	754	1,680	5,795	988	1,015	705
17	1,690	810	2,565	3,940	906	1,875	....
18	1,690	761	2,308	3,228	930	2,280	....
19	1,570	740	2,850	2,760	850	1,750	....
20	1,482	740	2,280	2,850	810	1,750	....
21	1,350	740	2,350	2,005	775	2,940	....
22	1,250	705	2,790	1,875	740	4,120	....
23	1,280	684	2,490	1,750	726	2,715	....
24	3,940	726	2,850	1,680	670	1,940	....
25	4,080	705	2,070	1,405	670	1,750	....
26	2,972	705	2,044	1,460	670	1,666	....
27	2,280	622	2,308	1,750	684	2,238	....
28	2,112	705	3,855	1,875	740	2,865	....
29	2,070	....	4,980	1,810	1,015	1,940	....
30	2,005	....	4,490	1,690	810	1,750	....
31	2,005	....	4,120	....	1,078	....	....

NOTE.—Discharge computed from a rating curve well defined between 320 and 1,690 second-feet.

Monthly discharge of South Fork of Shenandoah River near Front Royal, Va., 1899–1906.

[Drainage area, 1,570 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1899					
June 26-30	650	547	594	.378	.070
July	950	428	538	.343	.395
August	1,275	350	599	.382	.440
September	2,080	485	759	.484	.540
October	685	455	559	.356	.410
November	6,110	650	1,236	.788	.879
December	3,920	515	1,121	.714	.823
1900					
January	12,800	950	2,265	1.44	1.66
February	8,060	950	2,492	1.59	1.66
March	12,680	1,680	3,551	2.26	2.61
April	3,490	1,120	1,755	1.12	1.25
May	2,010	720	1,160	.739	.852
June	5,890	650	1,708	1.09	1.22
July	1,120	515	776	.495	.571
August	795	400	538	.343	.395
September	1,070	350	499	.318	.355
October	3,920	547	1,042	.664	.765
November	7,005	580	1,285	.819	.914
December	5,150	720	1,417	.903	1.04
The year	12,800	350	1,540	.982	13.29

Monthly discharge of South Fork of Shenandoah River near Front Royal, Va., 1899–1906—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1901					
January	4,655	515	1,366	.871	1.00
February	1,220	580	818	.521	.542
March	11,580	515	1,975	1.26	1.45
April	46,200	1,810	8,374	5.34	5.96
May	40,900	1,680	5,768	3.68	4.24
June	11,720	1,940	4,302	2.74	3.06
July	15,070	1,440	3,912	2.49	2.87
August	6,440	1,075	3,204	2.04	2.35
September	7,580	720	1,825	1.16	1.29
October	9,730	758	2,020	1.29	1.49
November	2,595	650	966	.616	.687
December	43,500	1,220	5,984	3.81	4.39
The year	46,200	515	3,319	2.11	29.33
1902					
January	9,600	1,385	3,730	2.38	2.74
February	54,700	1,330	6,439	4.10	4.27
March	76,800	3,070	9,871	6.29	7.25
April	12,260	1,560	3,826	2.44	2.72
May	3,150	910	1,579	1.01	1.16
June	1,030	650	861	.549	.612
July	1,680	515	754	.481	.554
August	795	400	571	.364	.420
September	2,370	305	531	.338	.377
October	2,370	455	848	.540	.623
November	2,750	455	784	.500	.558
December	6,220	1,440	3,040	1.94	2.24
The year	76,800	305	2,736	1.74	23.52
1903					
January	14,320	1,385	3,859	2.46	2.84
February	7,700	2,445	3,768	2.40	2.50
March	17,390	1,940	5,043	3.21	3.70
April	12,400	2,220	4,494	2.86	3.19
May	2,295	1,030	1,417	.903	1.04
June	13,610	1,560	4,308	2.74	3.06
July	7,225	910	2,338	1.49	1.72
August	2,010	650	1,046	.667	.769
September	5,570	650	1,738	1.11	1.24
October	2,370	650	842	.537	.619
November	870	580	691	.440	.491
December	1,680	580	853	.544	.627
The year	17,390	580	2,533	1.61	21.80
1904					
January	6,650	705	1,293	.824	.950
February	6,110	560	1,649	1.05	1.13
March	5,080	1,060	1,746	1.11	1.28
April	3,940	740	1,486	.947	1.06
May	5,480	1,150	1,875	1.20	1.38
June	3,430	740	1,375	.876	.977
July	6,215	560	1,117	.712	.821
August	1,105	350	613	.391	.451
September	640	320	395	.252	.281
October	368	320	326	.208	.240
November	368	320	329	.210	.234
December	1,150	320	530	.338	.390
The year	6,650	320	1,061	.676	9.19

Monthly discharge of South Fork of Shenandoah River near Front Royal, Va., 1899–1906—Continued.

Month	Discharge in second-feet: Maximum	Minimum	Mean	Per square mile	Run-off (depth in inches on drainage area)
1905					
January	2,005	425	917	.584	.673
February 1-27	6,320	560	1,140	.726	.729
March 5-31	6,870	1,405	3,104	1.98	1.99
April	1,810	740	1,143	.728	.812
May	2,005	560	920	.586	.676
June	9,380	465	1,372	.874	.975
July	5,480	890	2,236	1.42	1.64
August	3,068	560	1,014	.646	.745
September	1,200	417	595	.379	.423
October	474	350	417	.266	.307
November	474	378	425	.271	.302
December	7,024	425	1,476	.941	1.08
1906					
January	7,354	1,250	2,283	1.45	1.67
February	1,849	622	957	.610	.635
March	4,980	652	2,233	1.42	1.64
April	5,795	1,405	2,393	1.52	1.70
May	1,594	670	1,049	.668	.770
June	4,120	610	1,464	.932	1.04
July 1-16	1,875	706	1,139	.725	.431

NOTE.—Drainage area of 1,569 square miles used previous to 1906. No corrections made for effect of ice during winter months.

SHENANDOAH RIVER AT MILLVILLE, W. VA.

Location.—At a ferry about one-fourth mile above the Baltimore & Ohio Railroad station at Millville, and about 4½ miles above Harper's Ferry and the mouth of the river.

Drainage area.—3,000 square miles.

Records available.—April 15, 1895, to March 31, 1909.

Gage.—Vertical staff spiked to a sycamore tree on the left bank; read once daily.

Discharge measurements.—Made from a cable about 200 feet above the gage.

Channel and control.—Both banks are low and liable to overflow. Current swift and unobstructed. Bed of stream composed of mud and rocks.

Extremes of discharge.—Maximum stage: 19.7 feet, estimated, on October 1, 1896; discharge, 139,700 second-feet. Minimum stage: 0.4 foot in October and November, 1904; discharge, 480 second-feet.

Winter flow.—Discharge relation somewhat affected by ice.

Accuracy.—Results probably reliable for discharges below 15,000 second-feet; above 15,000 second-feet the probable error may be 10 to 15 per cent or, at extreme flood stages, even greater.

Discharge measurements of Shenandoah River at Millville, W. Va., in 1906–1908.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
1906			
May 29	Robert Follansbee	1.58	1,790
1908			
January 15 [a]	F. F. Henshaw	6.93	18,400

[a] Surface velocities observed; coefficient of 0.9 used to reduce to mean velocity.

Daily gage height, in feet, of Shenandoah River at Millville, W. Va., for 1906–1909.

[W. R. Nicewarner, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	2.7	2.3	1.1	4.75	2.3	1.5	2.0	1.8	3.55	1.45	2.7	1.85
2	2.45	2.2	1.1	4.2	2.2	1.5	1.8	1.4	3.8	1.45	2.5	1.8
3	2.25	2.0	1.2	3.8	2.1	1.4	1.6	1.8	2.7	1.4	2.4	1.75
4	3.4	2.4	2.2	3.4	2.0	1.3	1.3	1.4	2.2	1.7	2.3	1.7
5	5.3	2.0	2.5	3.1	1.95	1.2	2.15	2.5	2.2	2.5	2.2	1.65
6	4.5	1.95	3.5	2.9	1.9	2.1	1.7	2.3	2.0	3.5	2.1	1.7
7	3.6	1.9	2.9	2.7	1.85	1.3	1.55	2.1	1.9	3.1	2.05	1.65
8	3.0	1.8	2.5	2.6	1.8	1.2	1.6	2.0	1.8	2.6	2.0	1.6
9	2.7	1.6	2.3	2.4	2.1	1.2	1.5	2.2	1.65	2.3	1.9	1.55
10	2.45	1.6	2.1	2.45	2.05	1.65	1.35	2.3	1.6	2.05	1.85	1.5
11	2.3	1.75	2.0	2.6	1.9	1.9	1.3	2.0	1.5	1.8	1.8	1.6
12	2.15	1.5	1.9	2.6	1.85	1.5	1.3	2.0	1.5	1.8	1.8	1.65
13	2.0	1.45	1.75	2.45	1.8	1.2	1.3	3.0	1.45	1.65	1.75	1.55
14	2.0	1.3	1.7	2.3	1.7	1.2	1.3	3.4	1.9	1.5	1.75	1.5
15	2.0	1.35	1.7	3.2	1.6	1.2	1.4	3.8	1.6	1.4	1.75	1.4
16	2.2	1.3	1.8	4.7	1.55	2.0	1.3	3.9	1.5	1.4	1.7	1.45
17	2.3	1.8	1.9	4.2	1.4	2.6	1.3	3.2	1.35	1.4	1.65	1.7
18	2.25	1.2	2.6	3.6	1.35	2.1	1.3	4.1	1.3	1.5	1.6	4.2
19	2.2	1.2	2.7	3.2	1.45	3.8	1.4	3.35	1.35	4.1	1.8	4.5
20	2.1	1.2	2.7	2.95	1.4	2.4	1.5	4.2	1.3	11.8	2.25	4.0
21	2.0	1.2	2.7	2.7	1.3	2.7	1.4	3.9	1.25	12.8	4.8	3.5
22	1.9	1.2	2.9	2.5	1.25	4.8	1.3	3.4	1.2	8.3	3.8	3.6
23	1.8	1.2	3.15	2.4	1.2	3.7	1.2	3.3	1.2	6.5	3.85	3.4
24	1.8	1.2	3.1	2.25	1.2	2.9	2.0	4.0	1.2	5.7	2.9	3.0
25	3.8	1.15	2.9	2.1	1.15	2.5	1.6	4.5	1.1	4.9	2.7	2.6
26	3.2	1.1	2.9	2.0	1.1	2.15	1.5	4.5	1.25	4.2	2.7	2.2
27	2.7	1.1	3.0	2.0	1.2	2.4	1.4	3.8	1.25	3.8	2.25	2.0
28	2.5	1.1	4.8	3.4	1.3	3.5	1.4	5.4	1.25	3.5	2.15	2.4
29	2.4	....	4.9	2.9	1.5	3.25	1.4	4.7	1.25	3.2	2.1	2.4
30	2.4	....	4.6	2.5	1.4	2.4	1.5	5.0	1.35	3.0	2.0	2.25
31	2.5	....	4.6	....	1.4	....	1.3	4.2	....	2.8	....	2.2
1907												
1	2.8	2.25	2.2	....	....	....	2.0	1.2	1.15	2.15	1.0	2.4
2	4.1	2.1	2.3	....	....	....	2.0	1.2	1.0	2.0	1.0	2.2
3	3.6	2.25	2.3	....	....	....	2.2	1.15	1.1	1.4	1.1	2.0
4	3.25	2.4	2.8	....	....	....	2.0	1.15	1.1	1.3	1.1	1.9
5	3.0	2.4	2.7	....	....	....	1.8	1.15	1.6	1.2	1.3	1.8
6	2.9	2.0	2.6	....	....	....	1.7	1.1	2.3	1.6	1.4	1.75
7	2.7	1.85	2.5	....	....	....	1.7	1.1	1.5	1.5	1.3	1.7
8	2.5	2.0	2.3	....	....	....	1.6	1.0	1.2	1.5	1.25	1.65
9	2.5	2.0	2.3	....	....	....	1.6	1.15	1.1	1.45	1.1	1.65
10	2.4	2.3	2.25	....	....	....	1.55	1.1	1.0	1.4	1.05	1.8
11	2.4	2.3	2.8	....	....	....	1.6	1.15	1.2	1.35	1.0	4.5
12	2.4	2.25	2.3	....	....	....	1.6	2.2	1.6	1.3	1.0	4.2
13	2.4	2.6	3.1	....	....	....	1.55	1.15	2.3	1.4	1.2	3.8
14	2.85	2.4	3.7	....	....	....	1.5	1.25	2.0	1.3	1.2	3.4
15	3.1	2.7	4.0	....	....	....	1.4	1.2	1.7	1.2	1.2	3.1
16	3.4	2.8	3.8	....	....	....	1.4	1.1	1.5	1.2	1.2	2.95
17	3.4	2.8	3.5	....	....	....	1.3	1.25	1.3	1.2	1.2	3.0
18	3.5	2.7	3.1	....	....	....	1.5	1.1	1.1	1.2	1.2	2.9
19	3.5	2.6	3.0	....	....	....	1.5	1.1	1.0	1.1	1.15	2.75
20	4.5	2.5	3.35	....	....	....	1.5	1.1	1.2	1.1	1.15	2.6
21	5.3	2.5	3.0	....	....	....	1.5	1.2	1.2	1.1	1.2	2.4
22	4.1	2.4	3.0	....	....	....	2.0	1.3	1.4	1.05	1.3	2.8
23	3.55	2.25	2.9	....	....	....	1.5	1.3	1.4	1.1	1.5	2.3
24	3.2	2.1	2.7	....	....	....	1.45	1.25	3.4	1.05	2.0	5.9
25	3.0	2.1	2.5	....	....	....	1.4	1.45	6.8	1.0	3.6	6.8

Daily gage height, in feet, of Shenandoah River at Millville, W. Va., for 1906–1909—
Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	2.8	2.1	2.4	....	....	....	1.35	2.0	3.9	1.0	4.6	5.5
27	2.7	2.1	2.3	....	....	....	1.3	1.55	2.9	1.0	3.8	4.4
28	2.5	2.2	2.25	....	....	....	1.3	1.4	2.5	1.0	3.2	3.5
29	2.4	....	2.2	....	....	....	1.3	1.3	2.3	1.0	2.9	3.2
30	2.4	....	2.0	....	....	....	1.3	1.2	2.2	1.0	2.6	3.0
31	2.3	....	2.0	....	....	....	1.25	1.2	....	1.0	....	2.85
1908												
1	2.75	2.6	3.2	2.3	1.45	3.2	1.5	1.6	2.5	1.6	2.8	1.15
2	2.7	2.4	3.4	2.4	1.45	2.8	1.5	1.4	1.8	1.4	2.4	1.15
3	2.6	2.2	4.0	2.45	1.45	2.5	2.0	1.2	1.65	1.2	2.1	1.2
4	2.45	2.1	4.3	2.45	1.5	2.3	1.6	1.1	1.5	1.15	1.9	1.1
5	2.35	2.05	4.1	2.4	1.6	3.3	1.6	1.15	1.4	1.05	1.7	1.05
6	2.3	2.0	3.9	2.35	1.8	3.4	1.6	1.1	1.45	1.0	1.6	1.1
7	2.25	2.1	4.5	2.3	2.75	3.3	1.5	1.1	1.5	1.0	1.55	1.1
8	2.25	2.4	4.4	2.3	4.9	2.9	1.5	1.1	1.45	1.0	1.5	1.05
9	2.3	2.4	4.2	2.25	4.2	2.6	1.55	1.4	1.4	1.0	1.4	1.15
10	2.25	2.2	4.0	2.15	4.0	2.6	1.4	1.2	1.4	.9	1.3	1.1
11	2.2	2.1	3.7	2.0	3.4	2.55	1.4	1.1	1.35	1.0	1.35	1.0
12	3.2	2.2	3.5	2.0	2.9	2.5	1.3	1.2	1.25	1.2	1.2	1.15
13	12.0	2.5	3.3	1.95	2.7	2.35	1.3	1.2	1.15	1.1	1.15	1.1
14	9.7	2.95	3.2	1.9	2.4	2.2	1.25	1.2	1.1	1.15	1.1	1.1
15	6.6	6.5	3.0	1.85	2.3	2.1	1.2	1.1	1.05	1.0	1.2	1.1
16	5.4	10.0	2.85	1.85	2.15	2.4	1.1	1.0	1.0	.95	1.25	1.1
17	4.6	7.8	2.75	1.8	2.0	4.0	1.0	1.1	1.0	.9	1.2	1.1
18	4.0	5.7	2.7	1.8	2.0	2.8	1.0	1.6	.95	.85	1.2	1.05
19	3.8	4.5	2.7	1.75	3.2	2.4	1.0	1.3	.9	.8	1.2	1.0
20	3.5	4.0	2.8	1.8	3.3	2.2	1.0	1.2	1.0	.9	1.15	1.0
21	3.4	3.7	2.75	1.75	4.4	2.0	1.0	1.1	.95	.85	1.3	1.0
22	3.35	3.4	2.7	1.65	9.4	2.1	1.0	1.0	.9	.85	1.4	1.0
23	3.3	3.2	2.7	1.6	8.5	1.9	1.0	1.0	.85	.8	1.5	1.05
24	3.2	3.0	2.6	1.6	7.4	1.9	1.1	.95	.85	.85	1.3	1.0
25	3.1	2.9	2.5	1.6	5.7	1.8	1.3	1.0	.85	1.2	1.3	1.0
26	3.0	3.0	2.4	1.55	4.7	1.8	2.9	2.3	.9	3.6	1.25	1.0
27	2.95	3.7	2.35	1.55	4.85	1.75	2.6	4.4	.9	2.5	1.25	1.1
28	2.95	3.5	2.4	1.5	3.9	1.7	2.4	4.2	.9	2.2	1.2	1.2
29	2.9	3.3	2.3	1.5	3.4	1.6	2.7	4.0	2.0	2.2	1.2	1.2
30	2.7	....	2.25	1.5	3.6	1.5	2.4	3.5	1.9	1.85	1.2	1.2
31	2.65	....	2.3	....	3.4	....	2.0	3.2	....	3.3	....	1.3

Day	Jan.	Feb.	Mar.	Day	Jan.	Feb.	Mar.
1909				**1909**			
1	1.5	2.2	3.0	16	2.0	2.6	2.2
2	2.35	2.1	2.8	17	2.2	2.6	2.1
3	2.3	2.0	2.8	18	2.3	2.5	2.0
4	2.0	2.0	3.0	19	2.5	2.5	1.95
5	2.0	1.9	3.1	20	2.4	2.5	1.9
6	2.0	1.8	2.9	21	2.3	2.9	1.8
7	3.0	1.8	2.85	22	2.2	2.95	1.8
8	2.9	1.8	2.8	23	2.5	2.9	1.75
9	2.5	1.8	2.75	24	4.7	3.5	1.75
10	2.3	2.0	2.6	25	5.1	3.6	1.7
11	2.0	3.5	2.65	26	4.5	3.8	1.7
12	2.0	4.5	2.55	27	3.2	3.55	1.8
13	1.95	3.7	2.5	28	3.0	3.3	2.0
14	1.8	3.2	2.4	29	2.8	....	2.2
15	1.8	2.9	2.3	30	2.6	....	2.1
				31	2.5	....	2.0

Daily discharge, in second-feet, of Shenandoah River at Millville, W. Va., for 1906–1909.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	3,730	2,940	1,090	9,370	2,940	1,580	2,380	1,320	5,700	1,520	3,730	2,120
2	3,230	2,750	1,090	7,560	2,750	1,580	2,030	1,450	6,380	1,520	3,330	2,030
3	2,845	2,380	1,200	6,380	2,560	1,450	1,720	2,030	3,730	1,450	3,130	1,950
4	5,320	2,380	2,750	5,820	2,380	1,320	1,320	1,450	2,750	1,870	2,940	1,870
5	11,400	2,380	3,330	4,600	2,290	1,200	2,660	3,330	2,750	3,330	2,750	1,800
6	8,520	2,290	5,570	4,150	2,200	2,560	1,870	2,940	2,380	5,570	2,560	1,870
7	5,830	2,200	4,150	3,730	2,115	1,320	1,650	2,560	2,200	4,600	2,470	1,800
8	4,370	2,030	3,330	3,530	2,030	1,200	1,720	2,380	2,030	3,530	2,380	1,720
9	3,730	1,720	2,940	3,130	2,560	1,200	1,580	2,750	1,800	2,940	2,200	1,650
10	3,230	1,720	2,560	3,230	2,470	1,795	1,380	2,940	1,720	2,470	2,120	1,580
11	2,940	1,950	2,380	3,530	2,200	2,200	1,320	2,380	1,580	2,030	2,080	1,720
12	2,655	1,580	2,200	3,530	2,115	1,580	1,320	2,380	1,580	2,030	2,030	1,800
13	2,380	1,515	1,950	3,230	2,080	1,200	1,320	4,370	1,520	1,800	1,950	1,650
14	2,380	1,320	1,870	2,940	1,870	1,200	1,320	5,320	2,200	1,580	1,950	1,580
15	2,380	1,385	1,870	4,840	1,720	1,200	1,450	6,380	1,720	1,450	1,950	1,450
16	2,750	1,320	2,030	9,200	1,650	2,380	1,320	6,670	1,580	1,450	1,870	1,520
17	2,940	1,320	2,200	7,560	1,450	3,530	1,320	4,840	1,380	1,450	1,800	1,870
18	2,845	1,200	3,530	5,830	1,385	2,560	1,320	7,260	1,320	1,580	1,720	7,560
19	2,750	1,200	3,730	4,840	1,515	6,380	1,450	5,200	1,380	7,260	2,080	8,520
20	2,560	1,200	3,730	4,260	1,450	3,130	1,580	7,560	1,320	47,600	2,840	6,960
21	2,380	1,200	3,730	3,730	1,320	3,730	1,450	6,670	1,260	60,800	7,880	5,570
22	2,200	1,200	4,150	3,330	1,260	9,540	1,320	5,320	1,200	25,800	6,380	5,830
23	2,030	1,200	4,720	3,130	1,200	6,100	1,200	5,080	1,200	16,500	6,520	5,820
24	2,030	1,200	4,600	2,845	1,200	4,150	2,380	6,960	1,200	13,000	4,150	4,370
25	6,380	1,145	4,150	2,560	1,145	3,330	1,720	8,520	1,090	9,900	3,730	3,580
26	4,840	1,090	4,150	2,380	1,090	2,655	1,580	8,520	1,260	7,560	3,730	2,750
27	3,730	1,090	4,370	2,380	1,200	3,130	1,450	6,380	1,260	6,380	2,840	2,380
28	3,330	1,090	9,540	5,320	1,320	5,570	1,450	11,800	1,260	5,570	2,660	3,130
29	3,130	....	9,900	4,150	1,580	4,960	1,450	9,200	1,260	4,840	2,560	3,130
30	3,130	....	8,860	3,330	1,450	3,130	1,580	10,300	1,380	4,370	2,380	2,840
31	3,330	....	8,860	....	1,450	....	1,320	7,560	....	3,940	....	2,750
1907												
1	3,940	2,840	2,750	....	....	....	2,380	1,200	1,150	2,660	980	3,130
2	7,260	2,560	2,940	....	....	....	2,380	1,200	980	2,380	980	2,750
3	5,830	2,840	2,940	....	....	....	2,750	1,150	1,090	1,450	1,090	2,380
4	4,960	3,130	3,940	....	....	....	2,380	1,150	1,090	1,320	1,090	2,200
5	4,370	3,130	3,730	....	....	....	2,030	1,150	1,720	1,200	1,320	2,030
6	4,150	2,380	3,530	....	....	....	1,870	1,090	2,940	1,720	1,450	1,950
7	3,730	2,120	3,330	....	....	....	1,870	1,090	1,580	1,580	1,320	1,870
8	3,330	2,380	2,940	....	....	....	1,720	980	1,200	1,580	1,260	1,800
9	3,330	2,380	2,940	....	....	....	1,720	1,150	1,090	1,520	1,090	1,800
10	3,130	2,940	2,840	....	....	....	1,650	1,090	1,980	1,450	1,040	2,030
11	3,130	2,940	3,940	....	....	....	1,720	1,150	1,200	1,380	980	8,520
12	3,130	2,840	2,940	....	....	....	1,720	2,750	1,720	1,320	980	7,560
13	3,130	3,530	4,600	....	....	....	1,650	1,150	2,940	1,450	1,200	6,380
14	4,040	3,130	6,100	....	....	....	1,580	1,260	2,380	1,320	1,200	5,320
15	4,600	3,730	6,960	....	....	....	1,450	1,200	1,870	1,200	1,200	4,600
16	5,320	3,940	6,380	....	....	....	1,450	1,090	1,580	1,200	1,200	4,260
17	5,320	3,940	5,570	....	....	....	1,320	1,260	1,320	1,200	1,200	4,370
18	5,570	3,730	4,600	....	....	....	1,580	1,090	1,090	1,200	1,200	4,150
19	5,570	3,530	4,370	....	....	....	1,580	1,090	980	1,090	1,140	3,840
20	8,520	3,330	5,200	....	....	....	1,580	1,090	1,200	1,090	1,140	3,580
21	11,400	3,330	4,370	....	....	....	1,580	1,200	1,200	1,090	1,200	3,130
22	7,260	3,130	4,370	....	....	....	2,380	1,320	1,450	1,040	1,320	2,940
23	5,700	2,840	4,150	....	....	....	1,580	1,320	1,450	1,090	1,580	2,940
24	4,840	2,560	3,730	....	....	....	1,520	1,260	5,320	1,040	2,380	13,800
25	4,370	2,560	3,330	....	....	....	1,450	1,520	17,800	980	5,830	17,800

Daily discharge, in second-feet, of Shenandoah River at Millville, W. Va., for 1906–1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	3,940	2,560	3,130	....	....	....	1,390	2,380	6,670	980	8,860	12,200
27	3,730	2,560	2,940	....	....	....	1,320	1,650	4,150	980	6,380	8,200
28	3,330	2,750	2,840	....	....	....	1,320	1,450	3,330	980	4,840	5,570
29	3,130	....	2,750	....	....	....	1,320	1,320	2,940	980	4,150	4,840
30	3,130	....	2,380	....	....	....	1,320	1,200	2,750	980	3,530	4,370
31	2,940	....	2,380	....	....	....	1,260	1,200	....	980	....	4,040
1908												
1	3,840	3,530	4,840	2,940	1,520	4,840	1,580	1,720	3,330	1,720	3,940	1,140
2	3,730	3,130	5,320	3,130	1,520	3,940	1,580	1,450	2,030	1,450	3,130	1,140
3	3,530	2,750	6,960	3,230	1,520	3,330	2,380	1,200	1,800	1,200	2,560	1,200
4	3,230	2,560	7,880	3,230	1,580	2,940	1,720	1,090	1,580	1,140	2,200	1,090
5	3,040	2,470	7,260	3,130	1,720	5,080	1,720	1,140	1,450	1,040	1,870	1,040
6	2,940	2,380	6,670	3,040	2,030	5,320	1,720	1,090	1,520	980	1,720	1,090
7	2,840	2,560	8,520	2,940	3,840	5,080	1,580	1,090	1,580	980	1,650	1,090
8	2,840	3,130	8,200	2,940	9,900	4,150	1,580	1,090	1,520	980	1,580	1,040
9	2,940	3,130	7,560	2,84	7,560	3,530	1,650	1,450	1,450	980	1,450	1,140
10	2,840	2,750	6,960	2,66	6,960	3,530	1,450	1,200	1,450	880	1,320	1,090
11	2,750	2,560	6,100	2,38	5,320	3,430	1,450	1,090	1,380	980	1,380	980
12	4,840	2,750	5,570	2,38	4,150	3,330	1,320	1,200	1,260	1,200	1,200	1,140
13	53,500	3,330	5,080	2,29	3,730	3,040	1,320	1,200	1,140	1,090	1,140	1,090
14	35,300	4,260	4,840	2,20	3,130	2,750	1,260	1,200	1,090	1,140	1,090	1,090
15	16,900	16,500	4,370	2,12	2,940	2,560	1,200	1,090	1,040	980	1,200	1,090
16	11,800	37,500	4,040	2,120	2,660	3,130	1,090	980	980	930	1,260	1,090
17	8,860	22,900	3,840	2,030	2,380	6,960	980	1,090	980	880	1,200	1,090
18	6,960	13,000	3,730	2,030	2,380	3,940	980	1,720	930	830	1,200	1,040
19	6,380	8,520	3,730	1,950	4,840	3,130	980	1,320	880	780	1,200	980
20	5,570	6,960	3,940	2,030	5,080	2,750	980	1,200	980	880	1,140	980
21	5,320	6,100	3,840	1,950	8,200	2,380	980	1,090	930	830	1,320	980
22	5,200	5,320	3,730	1,800	33,200	2,560	980	980	880	830	1,450	980
23	5,080	4,840	3,730	1,720	27,000	2,200	980	980	830	780	1,580	1,040
24	4,840	4,370	3,530	1,720	20,800	2,200	1,090	930	830	830	1,320	980
25	4,600	4,150	3,330	1,720	13,000	2,030	1,320	980	830	1,200	1,320	980
26	4,370	4,370	3,130	1,650	9,200	2,030	4,150	2,940	880	5,830	1,260	980
27	4,260	6,100	3,040	1,650	9,720	1,950	3,530	8,200	880	3,330	1,260	1,090
28	4,260	5,570	3,130	1,580	6,670	1,870	3,130	7,560	880	2,750	1,200	1,200
29	4,150	5,080	2,940	1,580	5,320	1,720	3,730	6,960	2,380	2,750	1,200	1,200
30	3,730	....	2,840	1,580	5,830	1,580	3,130	5,570	2,200	2,120	1,200	1,200
31	3,630	....	2,940	....	5,320	....	2,380	4,840	....	5,080	....	1,320

Day	Jan.	Feb.	Mar.	Day	Jan.	Feb.	Mar.
1909				**1909**			
1	1,580	2,750	4,370	16	2,380	3,530	2,750
2	3,040	2,560	3,940	17	2,750	3,530	2,560
3	2,940	2,380	3,940	18	2,940	3,330	2,380
4	2,380	2,380	4,370	19	3,330	3,330	2,290
5	2,380	2,200	4,600	20	3,130	3,330	2,200
6	2,380	2,030	4,150	21	2,940	4,150	2,030
7	4,370	2,030	4,040	22	2,750	4,260	2,030
8	4,150	2,030	3,940	23	3,330	4,150	1,950
9	3,330	2,030	3,840	24	9,200	5,570	1,950
10	2,940	2,380	3,530	25	10,600	5,830	1,870
11	2,380	5,570	3,630	26	8,520	6,380	1,870
12	2,380	8,520	3,430	27	4,840	5,700	2,030
13	2,290	6,100	3,330	28	4,370	5,080	2,380
14	2,030	4,840	3,130	29	3,940	....	2,750
15	2,030	4,150	2,940	30	3,530	....	2,560
				31	3,330	....	2,380

NOTE.—Discharge determined from a rating curve well defined between 480 and 11,000 second-feet. Discharge above 11,000 second-feet computed from a rating curve which is the product of a well-defined area curve and a fairly accurate extension of the velocity curve.

Monthly discharge of Shenandoah River at Millville, W. Va., for 1895–1909.

[Drainage area 3,000 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1895						
April 15-30	4,600	1,870	2,904	0.970	0.576	
May	20,780	2,560	5,570	1.86	2.14	
June	3,180	960	1,618	.539	.601	
July	7,260	960	1,880	.628	.724	
August	1,580	540	806	.269	.310	
September	1,320	610	722	.241	.269	
October	610	480	537	.179	.206	
November	690	540	621	.207	.231	
December	1,450	610	754	.252	.290	
1896						
January	11,400	880	2,434	.813	.937	
February	12,580	1,450	3,709	1.24	1.34	
March	12,180	1,450	3,842	1.28	1.48	
April	8,860	1,450	2,807	.937	1.05	
May	4,370	1,090	2,127	.710	.819	
June	3,940	780	2,056	.686	.765	
July	9,030	1,820	2,858	.954	1.10	
August	1,870	780	1,150	.384	.443	
September	13,190	540	1,042	.348	.388	
October	139,700	880	7,768	2.59	2.99	
November	4,840	880	1,835	.613	.684	
December	6,380	1,450	2,296	.767	.884	
The year	139,700	540	2,827	.944	12.88	
1897						
January	1,720	980	1,220	.407	.469	
February (25 days)	37,870	1,090	11,680	3.90	3.63	
March	6,760	2,590	4,946	1.65	1.90	
April	3,350	1,620	2,671	.892	.995	
May	30,620	1,760	6,243	2.08	2.40	
June	2,410	1,010	1,632	.545	.608	
July	3,770	910	1,426	.476	.549	
August	1,760	730	987	.330	.380	
September	1,350	580	664	.222	.248	
October	1,010	550	692	.231	.266	
November	1,620	650	859	.287	.320	
December	3,990	820	1,619	.541	.624	
1898						
January	6,180	1,010	2,435	.813	.937	
February	2,770	1,010	1,612	.538	.560	
March	5,650	1,010	2,227	.744	.858	
April	13,120	2,070	4,353	1.45	1.62	
May	29,150	2,070	5,711	1.91	2.20	
June	2,410	1,120	1,647	.550	.614	
July	3,770	820	1,249	.417	.481	
August	50,900	1,350	8,164	2.73	3.15	
September	1,835	1,120	1,360	.454	.506	
October	30,500	1,010	5,684	1.90	2.19	
November	4,210	2,070	2,827	.944	1.05	
December	14,780	2,410	4,498	1.50	1.73	
The year	50,900	820	3,481	1.16	15.90	

Monthly discharge of Shenandoah River at Millville, W. Va., for 1895–1909—Contd.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1899						
January	17,840	2,770	5,116	1.71	1.97	
February 1-21	7,380	2,070	3,675	1.23	.960	
March 10-31	12,720	4,440	7,065	2.36	1.93	
April	4,910	2,070	3,289	1.10	1.23	
May	4,910	1,480	2,533	.846	.975	
June	4,670	1,010	1,607	.537	.599	
July	1,760	730	877	.293	.338	
August	1,910	650	992	.331	.382	
September	1,760	730	989	.330	.368	
October	910	650	785	.262	.302	
November	5,150	910	1,403	.468	.522	
December	4,440	820	1,398	.467	.538	
1900						
January	14,780	1,230	2,970	.992	1.14	
February	14,360	1,350	3,833	1.28	1.33	
March	16,960	2,590	5,866	1.96	2.26	
April	4,670	1,835	2,803	.936	1.04	
May	2,410	1,230	1,689	.564	.650	
June	9,020	1,010	2,249	.751	.838	
July	4,210	775	1,374	.459	.529	
August	1,290	690	829	.277	.319	
September	1,230	580	696	.232	.259	
October	2,770	650	947	.316	.364	
November	9,020	730	1,453	.485	.541	
December	10,060	1,010	2,232	.745	.859	
The year	16,960	580	2,245	.750	10.13	
1901						
January	5,910	820	1,812	.605	.698	
February	3,150	730	1,315	.439	.457	
March	20,620	820	3,376	1.13	1.30	
April	50,000	2,500	12,840	4.29	4.79	
May	45,920	2,590	8,704	2.91	3.36	
June	38,240	3,770	8,225	2.75	3.07	
July	13,940	1,290	4,437	1.48	1.71	
August	11,180	1,620	3,528	1.18	1.36	
September	11,940	1,230	2,496	.833	.929	
October	6,460	1,120	1,769	.591	.681	
November	3,990	910	1,341	.448	.500	
December	50,000	1,350	8,124	2.71	3.12	
The year	50,000	730	4,831	1.61	21.98	
1902						
January	21,100	2,240	5,176	1.73	1.99	
February	50,000	1,120	8,611	2.88	3.00	
March	77,900	4,100	13,880	4.63	5.34	
April	20,140	2,960	6,785	2.27	2.53	
May	7,380	1,760	2,606	.870	1.00	
June	1,910	1,120	1,402	.468	.522	
July	1,620	865	1,097	.366	.422	
August	2,410	775	1,062	.355	.409	
September	1,120	650	724	.242	.270	
October	2,155	775	1,069	.357	.412	
November	3,560	730	1,157	.386	.431	
December	9,020	2,240	4,728	1.58	1.82	
The year	77,900	650	4,025	1.34	18.15	

Monthly discharge of Shenandoah River at Millville, W. Va., for 1895–1909—Contd.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1903						
January	27,900	2,070	6,802	2.27	2.62	
February	9,360	2,770	5,448	1.82	1.90	
March	22,060	3,560	7,907	2.64	3.04	
April	23,060	8,665	7,880	2.63	2.93	
May	3,560	1,760	2,821	.775	.894	
June	31,200	2,240	7,448	2.49	2.78	
July	9,530	1,415	3,453	1.15	1.33	
August	2,590	1,065	1,590	.531	.612	
September	9,360	1,230	2,249	.751	.838	
October	2,770	1,065	1,454	.485	.559	
November	1,120	730	961	.321	.358	
December	1,620	650	927	.310	.357	
The year	31,200	650	4,037	1.35	18.22	
1904						
January 1-24	3,770	910	1,428	.477	.426	
February	....	....	....	....	....	
March 8-31	9,900	1,515	2,546	.850	.759	
April	7,880	1,090	2,191	.732	.817	
May	5,570	1,650	2,779	.928	1.07	
June	6,960	1,090	2,430	.811	.905	
July	12,580	1,090	1,930	.644	.742	
August	2,030	575	1,096	.366	.422	
September	880	510	620	.207	.231	
October	610	480	521	.174	.201	
November	610	480	528	.176	.196	
December	2,845	510	780	.260	.300	
1905						
January	4,150	830	2,065	.689	.794	
February	4,370	1,200	1,684	.562	.585	
March	9,370	2,560	4,387	1.46	1.68	
April	8,230	1,200	1,945	.649	.724	
May	2,940	880	1,382	.461	.531	
June	13,820	690	2,552	.852	.950	
July	11,400	1,450	2,994	1.00	1.15	
August	4,840	930	1,557	.520	.600	
September	1,145	575	810	.270	.301	
October	880	540	640	.214	.247	
November	690	575	624	.208	.232	
December	11,400	610	2,336	.780	.899	
The year	13,820	540	1,915	.639	8.69	
1906						
January	11,400	2,030	3,720	1.24	1.43	
February	2,940	1,090	1,640	.548	.57	
March	9,900	1,090	3,890	1.30	1.50	
April	9,370	2,380	4,460	1.49	1.66	
May	2,940	1,090	1,800	.601	.69	
June	9,540	1,200	2,900	.965	1.08	
July	2,660	1,200	1,580	.527	.61	
August	11,800	1,320	5,220	1.74	2.01	
September	6,380	1,090	1,980	.660	.74	
October	60,800	1,450	8,250	2.75	3.17	
November	7,880	1,720	3,020	1.01	1.13	
December	8,520	1,450	3,050	1.02	1.18	
The year	60,800	1,090	3,460	1.15	15.77	

Monthly discharge of Shenandoah River at Millville, W. Va., for 1895–1909—Contd.

Month	Discharge in second-feet: Maximum	Minimum	Mean	Per square mile	Run-off (depth in inches on drainage area)	Accuracy
1907						
January	11,400	2,940	4,710	1.57	1.81	A.
February	3,940	2,120	2,990	.997	1.04	A.
March	6,960	2,380	3,840	1.28	1.46	A.
April	....	....	4,600	1.53	1.71	D.
May	....	....	3,400	1.13	1.30	D.
June	....	....	7,200	2.40	2.68	D.
July	2,750	1,260	1,700	.567	.65	A.
August	2,750	980	1,300	.433	.50	A.
September	17,800	980	2,570	.857	.96	A.
October	2,660	980	1,300	.433	.50	A.
November	8,860	980	2,100	.700	.78	A.
December	17,800	1,800	4,890	1.63	1.88	A.
The year	....	980	3,380	1.13	15.27	
1908						
January	53,500	2,750	7,550	2.52	2.90	A.
February	37,500	2,380	6,640	2.21	2.38	A.
March	8,520	2,840	4,890	1.63	1.88	A.
April	3,230	1,580	2,290	.763	.85	A.
May	32,200	1,520	7,070	2.36	2.72	A.
June	6,960	1,580	3,240	1.08	1.20	A.
July	4,150	980	1,740	.580	.67	A.
August	8,200	930	2,120	.707	.82	A.
September	3,330	830	1,330	.443	.49	A.
October	5,830	780	1,530	.510	.59	A.
November	3,940	1,090	1,550	.517	.58	A.
December	1,320	980	1,080	.360	.42	A.
The year	53,500	780	3,420	1.14	15.50	
1909						
January	10,600	1,580	3,630	1.21	1.40	B.
February	8,520	2,080	3,930	1.31	1.36	B.
March	4,600	1,870	3,010	1.00	1.15	B.

NOTE.—Drainage area of 2,995 square miles used previous to 1906. Ice present during January and Dec. 24-31, 1897; February, 1898, and January and February, 1899; estimates not corrected. Backwater from ice Feb. 5-6, 1900; discharge estimates corrected. Slight backwater from ice during part of January and February, 1901; no correction made in discharge estimates. Apr. 22 and Dec. 31, 1901, river out of banks; discharge estimated 50,000 second-feet. Ice present during part of February, 1902; no correction made in discharge estimates. Feb. 26-27, 1902, river out of banks; discharge estimated 50,000 second-feet. Backwater Dec. 16, 1903, during part of December, 1904; Mar. 6, 1905; and Feb. 4, 1906; discharge estimates corrected. Mean monthly discharge for April, May, and June, 1907, computed from discharge at Point of Rocks, using same rate of discharge per square mile.

LEWIS CREEK NEAR STAUNTON, VA.

Location.—At a private bridge on property of William Glenn, about a mile below a railroad bridge, and about 2 miles northeast of Staunton.

Drainage area.—20 square miles.

Records available.—July 1, 1905, to July 15, 1906.

Gage.—Vertical staff fastened to a tree on left bank just below bridge; read once daily.

Discharge measurements.—Made from the bridge.

Channel and control.—Both banks are about 5 feet high; neither overflows except during very high water. Bed of stream is soft mud which shifts. Current sluggish.

Extremes of discharge.—Maximum stage recorded: 1.94 feet, June 25, 1906; discharge, 92 second-feet. Minimum stage recorded: 0.33 foot, May 17, 1906; discharge, 1.2 second-feet.

Winter flow.—Discharge relation probably not affected by ice during winter of 1905-6.

Accuracy.—Results fair previous to the high water of May, 1906; approximate for high-water periods and after the flood in May, 1906.

Discharge measurements of Lewis Creek near Staunton, Va., in 1906.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
April 10	Robert Follansbee	0.83	12.5
June 14	Follansbee and Padgett	.55	6.6

Daily gage height, in feet, of Lewis Creek near Staunton, Va., for 1906.

[Ashby Glenn, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	0.54	0.49	0.74	0.74	0.48	0.54	0.64
2	.43	.58	.70	.70	.53	.53	.53
3	.54	.60	.71	.64	.60	.54	.54
4	1.43	.53	.53	.49	.49	.58	.53
5	.94	.54	.64	.54	.53	.59	.49
6	.83	.53	.59	.48	.54	.48	.53
7	.64	.49	.54	.44	.53	.54	.64
8	.53	.53	.53	.57	.54	.58	.53
9	.49	.44	.71	.44	.43	.49	.54
10	.43	.48	.53	.83	.49	.53	.48
11	.59	.44	.54	.84	.48	.44	.44
12	.48	.53	.59	.73	.49	.53	.48
13	.60	.49	.74	.79	.43	.54	.53
14	.53	.59	.63	.63	.44	.53	.64
15	.59	.54	1.04	.74	.48	.49	.43
16	.53	.48	.83	.63	.49	.63	....
17	.44	.54	.84	.74	.33	.49	....
18	.48	.53	.83	.53	.34	.43	....
19	.59	.49	.84	.49	.48	.49	....
20	.53	.43	.78	.53	.44	.53	....
21	.74	.49	.74	.49	.43	.49	....
22	.63	.53	.70	.53	.49	.43	....
23	.74	.54	.64	.64	.38	.44	....
24	.63	.43	.63	.63	.34	.93	....
25	.54	.54	.64	.54	.33	1.94	....
26	.48	.53	.59	.54	.94	1.83	....
27	.54	.49	.54	.59	1.18	.94	....
28	.63	.43	1.13	.49	1.64	.73	....
29	.54	....	.84	.63	1.13	.54	....
30	.48	....	.93	.64	.64	.53	....
31	.44	....	1.24	....	.58	....	....

NOTE.—Discharge relation probably unaffected by ice.

Daily discharge, in second-feet, of Lewis Creek near Staunton, Va., for 1905–6.

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905							1905						
1	6.8	2.6	3.4	1.9	1.9	3.4	16	4.4	3.4	3.4	1.9	3.4	6.8
2	14.1	4.4	1.9	1.9	3.4	3.4	17	3.4	2.6	3.4	3.4	2.6	3.4
3	8.2	2.6	2.6	6.8	3.4	5.5	18	3.4	5.5	2.6	2.6	9.7	3.4
4	6.8	2.6	1.9	1.9	3.4	1.9	19	4.4	3.4	2.6	2.6	2.6	3.4
5	3.4	5.5	2.6	1.9	3.4	3.4	20	1.9	2.6	2.6	5.5	1.9	2.6
6	3.4	3.4	2.6	1.4	5.5	3.4	21	3.4	2.6	2.6	5.5	2.6	1.9
7	8.2	3.4	2.6	1.9	6.8	2.6	22	21.0	2.6	3.4	3.4	4.4	2.6
8	5.5	2.6	2.6	1.9	3.4	3.4	23	5.5	4.4	2.6	5.5	1.4	2.6
9	4.4	3.4	2.6	5.5	1.9	3.4	24	5.5	2.6	2.6	8.2	1.4	3.4
10	3.4	2.6	2.6	3.4	1.9	1.9	25	4.4	3.4	2.6	6.8	3.4	3.4
11	3.4	1.4	2.6	18.9	4.4	1.9	26	3.4	3.4	1.9	5.5	3.4	3.4
12	23.5	2.6	2.6	11.3	3.4	1.9	27	5.5	3.4	1.9	5.5	3.4	2.6
13	8.2	2.6	3.4	8.2	5.5	2.6	28	2.6	3.4	1.9	5.5	2.6	6.8
14	3.4	2.6	5.5	3.4	5.5	3.4	29	3.4	3.4	1.9	1.9	1.9	4.4
15	4.4	3.4	5.5	1.9	3.4	5.5	30	2.6	1.9	1.9	2.6	1.9	3.4
							31	3.4	3.4	......	3.4	......	1.9

Daily discharge, in second-feet, of Lewis Creek near Staunton, Va., for 1905–6—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	4.2	3.2	9.4	9.4	3.1	6.3	9.1
2	2.3	4.0	8.2	8.2	4.0	6.0	6.0
3	4.2	5.5	8.5	6.5	5.5	6.3	6.3
4	44.9	4.0	4.0	3.2	3.2	7.3	6.0
5	16.4	4.2	6.5	4.2	4.0	7.6	5.1
6	12.4	4.0	5.3	3.1	4.2	4.9	6.0
7	6.5	3.2	4.2	2.5	4.0	6.3	9.1
8	4.0	4.0	4.0	4.8	4.2	6.0	6.0
9	3.2	2.5	8.5	2.5	2.3	5.1	6.3
10	2.3	3.1	4.0	12.3	3.2	6.0	4.9
11	5.3	2.5	4.2	12.7	3.1	4.0	4.0
12	3.1	4.0	5.3	9.1	3.2	6.0	4.9
13	7.9	3.2	9.4	11.0	2.3	6.3	6.0
14	4.0	5.3	6.3	6.3	2.5	6.0	9.1
15	5.3	4.2	20.6	9.4	3.1	5.1	3.8
16	4.0	3.1	12.3	6.3	3.2	8.8	....
17	2.5	4.2	12.7	9.4	1.2	5.1	....
18	3.1	4.0	12.3	4.0	1.3	3.8	....
19	5.3	3.2	12.7	3.2	3.1	5.1	....
20	4.0	2.3	10.7	4.0	2.5	6.0	....
21	9.4	3.2	9.4	3.2	2.3	5.1	....
22	6.3	4.0	8.2	4.0	3.2	3.8	....
23	9.4	4.2	6.5	6.5	1.7	4.0	....
24	6.3	2.3	6.3	6.3	1.3	19.6	....
25	4.2	4.2	6.5	4.2	1.2	92	....
26	3.1	4.0	5.3	4.2	16.4	82	....
27	4.2	3.2	4.2	5.3	27.8	20.1	....
28	6.3	2.3	25.0	3.2	66	12.0	....
29	4.2	....	12.7	6.3	30.3	6.3	....
30	3.1	....	16.0	6.5	9.1	6.0	....
31	2.5	....	31.4	....	7.3	....	....

NOTE.—Discharge July 1, 1905, to May 27, 1906, computed from a rating curve fairly well defined between 3.5 and 12 second-feet. Discharge May 28 to July 15, 1906, computed from a rating curve based on one measurement and the form of the preceding curve.

Monthly discharge of Lewis Creek near Staunton, Va., for 1905–6.

[Drainage area, 20 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1905					
July	24.	1.9	6.0	0.299	0.34
August	5.5	1.4	3.2	.158	.18
September	5.5	1.9	2.8	.138	.15
October	19.	1.4	4.6	.229	.26
November	9.7	1.4	3.5	.173	.19
December	6.8	1.9	3.3	.167	.19
1906					
January	45.	2.3	6.6	.329	.38
February	5.5	2.3	3.6	.180	.19
March	31.	4.0	9.7	.485	.56
April	13.	2.3	6.1	.303	.34
May	66.	1.2	7.4	.370	.43
June	92.	3.8	12.3	.615	.69
July 1–15	9.1	3.8	6.2	.308	.17

NOTE.—Results rated as follows: July and October, 1905, and January, March, April, and May, 1906, good; remainder of the period, fair, except June, which is approximate; discharge below 2 second-feet and above 30 second-feet, approximate.

COOKS CREEK AT MOUNT CRAWFORD, VA.

Location.—At the upper highway bridge, three-fourths mile east of Mount Crawford.

Drainage area.—41 square miles.

Records available.—July 1, 1905, to July 15, 1906.

Gage.—Chain on downstream side of bridge; read once daily.

Discharge measurements.—Made from the bridge or by wading.

Channel and control.—Both banks overflow during high water, but all the water passes beneath the bridge. Bed composed of mud and gravel. Current very sluggish at low stages.

Extremes of discharge.—Maximum stage recorded: 5.5 feet, July 5, 1905; discharge, 346 second-feet. Minimum stage recorded, 1.70 feet, September to December, 1905; discharge, 10 second-feet. These maxima and minima are approximate.

Winter flow.—Discharge relation probably unaffected by ice during winter of 1905-6.

Accuracy.—Results, except at stages covered by measurements, are approximate.

The following discharge measurement was made by Robert Follansbee:

April 10, 1906: Gage height, 2.32 feet; discharge, 32.4 second-feet.

Daily gage height, in feet, of Cooks Creek at Mount Crawford, Va., for 1906.

[S. H. Craun, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	2.05	2.0	2.0	2.5	2.1	2.0	2.1
2	2.05	2.0	2.0	2.4	2.1	2.0	2.1
3	2.05	1.8	2.0	2.3	2.1	2.0	2.1
4	3.0	2.0	2.4	2.3	2.1	2.0	2.1
5	2.5	2.0	2.2	2.2	2.1	2.0	2.0
6	2.3	2.1	2.1	2.3	2.1	1.9	2.0
7	2.3	2.0	2.1	2.2	2.2	1.9	2.0
8	2.2	2.0	2.1	2.2	2.2	1.9	2.0
9	2.2	2.0	2.1	2.3	2.1	1.9	2.0
10	2.1	2.0	2.1	2.3	2.1	1.9	2.0
11	2.1	2.1	2.1	2.2	2.1	1.9	3.0
12	2.1	2.0	2.1	2.2	2.0	1.9	2.1
13	2.1	2.0	2.05	2.2	2.1	1.8	2.0
14	2.3	2.0	2.4	2.2	2.1	1.8	2.0
15	2.3	2.0	2.6	2.5	2.0	1.8	2.0
16	2.2	1.9	2.5	2.4	2.0	1.8	......
17	2.2	2.0	2.4	2.3	2.0	2.0	......
18	2.2	2.0	2.3	2.2	2.0	2.0	......
19	2.1	1.9	2.4	2.2	2.0	2.0	......
20	2.1	1.9	2.3	2.2	2.0	2.5	......
21	2.1	2.0	2.3	2.2	1.9	2.1	......
22	2.1	2.0	2.3	2.2	1.9	2.2	......
23	2.3	2.0	2.3	2.2	1.9	2.1	......
24	2.3	1.8	2.3	2.1	2.0	2.0	......
25	2.2	2.0	2.3	2.1	2.0	2.0	......
26	2.1	2.0	2.3	2.2	2.0	2.1	......
27	2.1	2.0	2.6	2.2	2.0	3.0	......
28	2.2	2.0	2.5	2.1	2.0	2.0	......
29	2.2	......	2.5	2.1	2.0	2.2	......
30	2.1	......	2.4	2.1	2.0	2.1	......
31	2.1	......	2.5	......	2.0	......	......

Daily discharge, in second-feet, of Cooks Creek at Mount Crawford, Va., for 1905–6.

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905							1905						
1	23	27	13	13	10	13	16	36	19	13	10	10	10
2	23	27	16	13	10	13	17	31	16	13	10	10	10
3	19	23	16	13	10	19	18	27	19	13	10	10	10
4	19	23	13	13	10	13	19	27	16	13	13	13	10
5	346	23	13	13	10	13	20	36	19	13	10	13	10
6	92	23	13	13	10	13	21	23	19	13	10	13	64
7	64	19	10	10	10	13	22	27	16	13	10	13	46
8	36	19	13	10	10	13	23	36	16	13	10	13	36
9	27	19	13	10	10	13	24	31	13	13	10	13	31
10	23	19	13	10	10	13	25	27	16	10	13	13	23
11	41	19	13	10	10	13	26	27	23	10	19	13	19
12	23	23	13	10	13	13	27	27	19	13	13	13	19
13	31	23	13	10	13	10	28	19	19	10	13	13	19
14	27	23	13	10	10	10	29	19	19	10	13	13	31
15	58	19	13	10	10	10	30	78	16	13	10	13	23
							31	36	16	......	10	......	27

Daily discharge, in second-feet, of Cooks Creek at Mount Crawford, Va., for 1905–6—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	21	19	19	41	23	19	23
2	21	19	19	36	23	19	23
3	21	13	19	31	23	19	23
4	71	19	36	31	23	19	23
5	41	19	27	27	23	19	19
6	31	23	23	31	23	16	19
7	31	19	23	27	27	16	19
8	27	19	23	27	27	16	19
9	27	19	23	31	23	16	19
10	23	19	23	31	23	16	19
11	23	23	23	27	23	16	71
12	23	19	23	27	19	16	23
13	23	19	21	27	23	13	19
14	31	19	36	27	23	13	19
15	31	19	46	41	19	13	19
16	27	16	41	36	19	13	....
17	27	19	36	31	19	19	....
18	27	19	31	27	19	19	....
19	23	16	36	27	19	19	....
20	23	16	31	27	19	41	....
21	23	19	31	27	16	23	....
22	23	19	31	27	16	27	....
23	31	19	31	27	16	23	....
24	31	13	31	23	19	19	....
25	27	19	31	23	19	19	....
26	23	19	31	27	19	23	....
27	23	19	46	27	19	71	....
28	27	19	41	23	19	19	....
29	27	....	41	23	19	27	....
30	23	....	36	23	19	23	....
31	23	....	41	....	19	....	....

NOTE.—Discharge determined from a rating curve fairly well defined between 20 and 40 second-feet and approximate beyond these limits.

Monthly discharge of Cooks Creek at Mount Crawford, Va., for 1905–6.

[Drainage area, 41 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1905					
July	346	19	43.8	1.07	1.23
August	27	13	19.7	.480	.55
September	16	10	12.7	.310	.35
October	19	10	11.4	.278	.32
November	13	10	11.4	.278	.31
December	64	10	18.7	.456	.53

Monthly discharge of Cooks Creek at Mount Crawford, Va., for 1905–6—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1906					
January	71	21	27.5	.671	.77
February	23	13	18.5	.451	.47
March	46	19	30.6	.746	.86
April	41	23	28.7	.700	.78
May	27	16	20.6	.502	.58
June	71	13	21.0	.512	.57
July 1-15	71	19	23.8	.580	.32

NOTE.—Results rated as follows: July, 1905, fair; August and December, 1905, good; September to November, 1905, approximate; 1906, good. Discharge determinations below 15 second-feet and above 60 second-feet, approximate. The rating curve used in the above determinations is virtually based on two measurements and hence is very uncertain.

ELK RUN AT ELKTON, VA.

Location.—At highway bridge 100 feet below railroad bridge, 500 feet south of the railroad station at Elkton, and about half a mile above the mouth.

Drainage area.—15.8 square miles.

Records available.—June 28, 1905, to July 15, 1906.

Gage.—Chain on downstream side of bridge; read once daily.

Discharge measurements.—Made from the highway bridge or from a footbridge about 1,000 feet downstream.

Channel and control.—Both banks overflow during high water. Current sluggish. Bed composed of gravel; practically permanent. Control section below gage shifts.

Extremes of discharge.—Maximum stage recorded: 4.5 feet, April 15, 1906; discharge, 132 second-feet. Minimum stage recorded: 2.4 feet in September, 1905; discharge, 5.5 second-feet.

Winter flow.—Discharge relation slightly affected by ice.

Accuracy.—Results only fair as a good rating curve could not be developed, because of changing conditions at the control section.

Discharge measurements of Elk Run at Elkton, Va., in 1906.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
April 11	Robert Follansbee	2.78	15.7
June 14	Follansbee and Padgett	2.57	6.5

Daily gage height, in feet, of Elk Run at Elkton, Va., for 1906.

[C. L. Gooden, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	2.85	2.9	2.7	3.1	2.9	2.67	2.5
2	2.8	2.95	2.7	3.8	2.88	2.5	2.5
3	2.75	2.9	3.35	3.0	2.75	2.6	2.5
4	3.25	2.9	3.3	2.95	2.8	2.65	2.6
5	3.1	2.9	2.9	2.85	2.8	2.51	2.5
6	3.0	2.85	2.85	2.9	2.9	2.6	3.5
7	2.91	2.85	2.8	2.85	2.95	2.59	2.8
8	2.8	2.8	2.8	2.8	2.9	2.5	2.78
9	2.96	2.8	2.81	2.95	2.8	2.6	2.7
10	2.91	2.8	2.7	2.8	2.87	2.58	2.72
11	2.9	2.8	2.8	2.85	2.85	2.53	2.7
12	2.8	2.78	2.75	2.8	2.7	2.6	2.72
13	2.8	2.77	2.85	2.8	2.75	2.58	2.7
14	2.8	2.75	2.95	2.85	2.7	2.47	2.7
15	3.0	2.7	3.0	4.5	2.55	2.58	2.75
16	2.9	2.77	3.1	3.5	2.64	2.6	....
17	2.85	2.7	3.0	3.2	2.6	2.6	....
18	2.8	2.7	2.95	3.0	2.6	2.65	....
19	2.8	2.8	2.9	2.95	2.6	2.7	....
20	2.75	2.72	2.85	2.85	2.6	3.65	....
21	2.75	2.7	2.9	2.9	2.55	2.9	....
22	2.8	2.78	2.9	2.9	2.62	3.2	....
23	3.0	2.77	2.85	2.85	2.6	2.9	....
24	3.1	2.8	2.8	2.8	2.5	2.87	....
25	3.0	2.75	2.7	2.8	2.6	2.82	....
26	2.95	2.78	2.9	2.95	2.62	2.72	....
27	3.0	2.75	2.85	3.0	2.5	2.63	....
28	3.15	2.75	2.9	2.95	2.72	2.6	....
29	2.95	....	3.0	2.95	2.7	2.6	....
30	3.0	....	2.9	2.85	2.65	2.55	....
31	2.9	....	3.1	....	2.7	....	....

Daily discharge, in second-feet, of Elk Run at Elkton, Va., for 1905–6.

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905							1905						
1	14	8.5	8.5	6.5	9.5	9.5	16	9.5	13	5.5	8	9.5	7.5
2	14	8	7	6.5	9.5	9.5	17	9.5	10.5	5.5	10	9.5	7.5
3	11	8	7	6.5	9.5	9.5	18	9.5	8.5	5.5	9	9.5	7.5
4	11	7	7	6	9.5	9.5	19	8.5	9.5	5.5	9	9.5	9.5
5	11	7	8.5	6	9.5	9.5	20	8	8.5	15	9	10.5	32
6	11	7	7	6.5	9.5	9.5	21	8	8.5	8.5	10	9.5	46
7	11	7	5.5	6.5	9.5	9.5	22	10.5	9.5	7	10	8.5	11.5
8	11	9.5	5.5	6.5	12	8.5	23	7	8.5	7	10	8.5	9.5
9	9	8.5	5.5	8	9.5	8.5	24	7	23	7	10	8.5	9.5
10	9	7	5.5	8	9.5	9.5	25	7	28	6.5	12	8.5	11.5
11	9	10.5	6	27	9.5	9.5	26	7	19	6.5	12	8.5	9.5
12	57	10.5	5.5	14.5	9.5	8.5	27	7	19	6.5	9.5	8.5	11.5
13	28	29	6	10	9.5	8.5	28	8.5	12.5	6.5	9.5	8.5	11.5
14	19	85	6	8	12	8.5	29	8.5	10	6.5	9.5	8.5	17
15	12.5	19.5	6	8	9.5	7.5	30	8.5	10	6.5	9.5	8.5	15.5
							31	8.5	8.5	......	9.5	......	14

Daily discharge, in second-feet, of Elk Run at Elkton, Va., for 1905–6—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	13	15.5	11.5	29	17.5	9	6
2	11.5	18	11.5	89	17	6.5	6
3	10.5	16.5	42.5	24	13	8	6
4	29	16.5	38.5	21.5	14.5	8	7
5	21.5	16.5	17.5	17.5	14.5	6	6
6	17.5	15	15.5	19.5	17.5	7	44
7	14.5	15	14	17.5	19.5	7	11
8	11.5	13.5	15	16	16.5	6	11
9	16	13.5	15	21.5	13.5	7	9
10	14.5	13.5	12	16	15.5	7	9
11	14	13.5	15	17.5	15	6	9
12	11.5	13	13.5	16	13	7	9
13	11.5	12.5	16.5	16	12	7	9
14	11.5	12	20.5	17.5	13	5.5	9
15	17.5	11	22.5	132	8	6.5	10
16	15.5	12.5	27.5	58.5	9.5	7	....
17	14	11	22.5	35.5	8.5	7	....
18	12.5	11	20.5	24	8.5	7.5	....
19	12.5	14	18.5	21.5	8.5	8.5	....
20	11	12	16.5	16.5	8.5	54	....
21	11	11.5	18.5	18.5	7.5	13	....
22	12.5	13.5	18.5	18.5	9	24	....
23	19	13	16.5	16.5	8.5	13	....
24	23	14	15	15	7	12	....
25	19	12.5	13	15	8.5	11	....
26	17	13.5	19.5	20.5	8	9	....
27	19	12.5	17.5	23	6.5	7.5	....
28	25.5	12.5	19.5	20.5	10	7	....
29	17	....	24	19.5	9.5	7	....
30	19	....	19.5	16	8	6.5	....
31	15.5	....	29	....	9.5	....	....

NOTE.—Discharge obtained by indirect method for shifting channel.

Monthly discharge of Elk Run at Elkton, Va., for 1905–6.

[Drainage area, 15.8 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1905					
July	57	7.0	11.9	0.753	0.87
August	85	7.0	14.1	.892	1.03
September	15	5.5	6.7	.426	.48
October	27	6.0	9.4	.594	.68
November	12	8.5	9.4	.595	.66
December	46	7.5	11.8	.747	.86
1906					
January	29	10	15.8	1.00	1.15
February	18	11	13.5	.854	.89
March	42	11	19.3	1.22	1.41
April	132	15	27.0	1.71	1.91
May	20	6.5	11.5	.728	.84
June	54	5.5	9.9	.627	.70
July 1–15	44	6.0	10.7	.677	.38

NOTE.—Results for 1905 and 1906 are approximate, owing to shifting channel and insufficient discharge measurements.

HAWKSBILL CREEK NEAR LURAY, VA.

Location.—100 feet above a footbridge, 400 feet above mouth of Dry Run, and 1½ miles north of Luray.

Drainage area.—52 square miles.

Records available.—June 27, 1905, to July 15, 1906.

Gage.—Staff in two sections—lower inclined, upper vertical—attached to a tree on left bank; read once daily.

Discharge measurements.—Made from the footbridge or by wading.

Channel and control.—Left bank overflows at high water; right does not overflow. Bed composed of gravel; free from vegetation, and practically permanent. Rapids below the gage prevent backwater from Dry Run except during extreme floods.

Extremes of discharge.—Maximum stage: 3.35 feet, estimated, April 15, 1906; discharge, 430 second-feet. Minimum stage recorded: 1.3 feet in September, 1905; discharge, 24 second-feet. The highest known stage occurred October 13, 1893, and was determined from well-defined marks to have been 19.55 feet above the zero of the gage.

Winter flow.—Discharge relation probably unaffected by ice during the period of record.

Accuracy.—Results considered reliable except for extreme high and low stages.

Discharge measurements of Hawksbill Creek near Luray, Va., in 1906.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
April 12	Robert Follansbee	1.86	75
June 15 [a]	Follansbee and Padgett	1.50	36

[a] Wading below footbridge.

Daily gage height, in feet, of Hawksbill Creek near Luray, Va., for 1906.

[J. S. Miller, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	2.0	1.9	1.55	2.8	1.9	1.6	1.6
2	1.9	1.9	1.55	2.2	1.85	1.6	1.55
3	3.8	1.9	1.8	2.1	1.85	1.55	1.55
4	2.7	1.85	2.0	2.05	1.85	1.55	1.55
5	2.45	1.85	1.95	2.0	1.8	1.5	1.55
6	2.25	1.75	1.85	1.95	1.75	1.5	1.5
7	2.2	1.7	1.85	1.95	1.75	1.5	1.5
8	2.1	1.7	1.85	1.9	1.75	1.5	1.5
9	2.0	1.7	1.8	1.9	1.75	1.5	1.5
10	2.05	1.65	1.8	1.95	1.75	2.0	1.5
11	2.0	1.65	1.75	1.9	1.75	1.8	1.8
12	1.9	1.65	1.7	1.9	1.7	1.6	1.6
13	1.8	1.65	1.7	1.8	1.7	1.55	1.55
14	1.8	1.7	1.7	1.8	1.65	1.55	1.55
15	1.8	1.65	1.75	3.35	1.65	2.65	1.55
16	1.8	1.6	1.8	3.05	1.65	1.95	....
17	1.75	1.6	1.75	2.55	1.65	2.5	....
18	1.75	1.6	1.75	2.35	1.6	1.8	....
19	1.75	1.55	1.85	2.25	1.6	1.6	....
20	1.75	1.55	1.9	2.2	1.6	1.6	....
21	1.7	1.6	1.9	2.1	1.6	2.45	....
22	1.65	1.55	1.9	2.0	1.55	1.75	....
23	1.75	1.55	1.9	1.85	1.5	1.7	....
24	1.75	1.5	1.9	1.85	1.5	1.7	....
25	1.8	1.55	1.9	1.85	1.5	1.7	....
26	1.8	1.55	1.9	2.1	1.5	1.8	....
27	1.9	1.55	2.15	2.05	1.5	1.8	....
28	1.9	1.55	2.4	2.0	1.6	1.75	....
29	1.9	....	2.35	1.9	1.6	1.7	....
30	1.9	....	2.3	1.9	1.55	1.65	....
31	1.9	....	2.4	....	1.5	....	....

Daily discharge, in second-feet, of Hawksbill Creek near Luray, Va., for 1905–6.

Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905							
1	....	46	34	30	27	30	30
2	....	46	30	30	27	30	30
3	....	46	30	30	30	30	52
4	....	42	30	27	27	30	46
5	....	42	30	24	27	30	37
6	....	42	30	24	27	34	34
7	....	42	30	24	27	34	34
8	....	42	30	24	27	30	34
9	....	37	30	24	27	30	34
10	....	37	30	30	27	30	34
11	....	37	30	30	34	30	34
12	....	37	30	30	34	30	34
13	....	37	30	27	30	30	34
14	....	37	30	24	30	30	34
15	....	34	27	24	30	30	34

Daily discharge, in second-feet, of Hawksbill Creek near Luray, Va., for 1905–6—Continued.

Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905							
16	....	30	27	24	27	30	34
17	....	30	27	27	27	30	30
18	....	30	34	37	27	30	30
19	....	30	34	27	27	30	37
20	....	30	34	27	27	30	37
21	....	30	34	27	27	30	298
22	....	30	34	27	27	30	258
23	....	34	34	27	27	30	282
24	....	34	63	30	30	27	196
25	....	34	37	30	37	27	162
26	....	30	52	30	46	27	133
27	63	30	30	30	37	27	98
28	57	30	30	27	34	30	76
29	52	30	30	27	34	34	63
30	46	46	30	27	34	30	173
31	....	37	30	....	30	....	142

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	98	83	42	152	83	46	46
2	83	83	42	133	76	46	42
3	414	83	69	115	76	42	42
4	245	76	98	106	76	42	42
5	184	76	90	98	69	37	42
6	142	63	76	90	63	37	37
7	133	57	76	90	63	37	37
8	115	57	76	83	63	37	37
9	98	57	69	83	63	37	37
10	106	52	69	90	63	98	37
11	98	52	63	83	63	69	69
12	83	52	57	83	57	46	46
13	69	52	57	69	57	42	42
14	69	57	57	69	52	42	42
15	69	52	63	430	52	232	42
16	69	46	69	340	52	90	....
17	63	46	63	208	52	196	....
18	63	46	63	162	46	69	....
19	63	42	76	142	46	46	....
20	63	42	83	133	46	46	....
21	57	46	83	115	46	184	....
22	52	42	83	98	42	63	....
23	63	42	83	76	37	57	....
24	63	37	83	76	37	57	....
25	69	42	83	76	37	57	....
26	69	42	83	115	37	69	....
27	83	42	124	106	37	69	....
28	83	42	173	98	46	63	....
29	83	....	162	83	46	57	....
30	83	....	152	83	42	51	....
31	83	....	173	....	37	....	....

NOTE.—Discharge computed from a rating curve fairly well defined between 30 and 100 second-feet. Above and below these limits the probable error is about 10 per cent.

Monthly discharge of Hawksbill Creek near Luray, Va., for 1905–6.

[Drainage area, 52 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1905					
June 27-31	63	46	54.5	1.05	0.16
July	46	30	36.1	.694	.80
August	63	27	32.6	.627	.72
September	37	24	27.5	.529	.59
October	46	27	30.0	.577	.66
November	34	27	30.0	.577	.64
December	298	30	81.7	1.57	1.81
1906					
January	414	52	100	1.92	2.21
February	83	37	53.9	1.04	1.08
March	173	42	85.2	1.64	1.89
April	430	69	123	2.37	2.64
May	83	37	53.6	1.03	1.19
June	232	37	68.8	1.32	1.47
July 1-15	69	37	42.7	.821	.458

NOTE.—Results rated as follows: June to August, 1905, February, March, May to July, 1906, excellent; remainder of 1905 and 1906, good.

NORTH FORK OF SHENANDOAH RIVER NEAR RIVERTON, VA.

Location.—On the farm owned by L. W. Burke, about 2 miles above Riverton.

Drainage area.—1,040 square miles.

Records available.—June 26, 1899, to February 25, 1902; August 16, 1902, to July 14, 1906.

Gage.—Vertical staff, originally on right bank, removed to left bank and datum lowered 1 foot on September 10, 1900; read twice daily.

Discharge measurements.—Made from a cable about 100 feet below the gage.

Channel and control.—Both banks are low, fringed with trees, and liable to overflow. Bed of stream composed of rocks and mud; shifts somewhat. Discharge relation controlled by the dam at Riverton; height of this dam was increased from 8 feet to 10 feet in August, 1904.

Extremes of discharge.—Maximum stage observed: 17.5 feet at 6 P. M., April 21, 1901; discharge not computed. Minimum stage recorded: 3.5 feet during August, 1900; discharge, 90 second-feet.

Winter flow.—Discharge relation affected by ice to some extent.

Accuracy.—Estimates of discharge for low and medium stages probably reliable, but for higher stages not covered by measurements may be considerably in error. Measurement made in January, 1908, indicates that the rating curves used gave results too small at high stages, or that the control section has changed.

Discharge measurements of North Fork of Shenandoah River near Riverton, Va., in 1906 and 1908.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
1906			
April 13	Robert Follansbee	5.60	969
1908			
January 15 [a]	LaRue and Follansbee	7.9	3,960

[a] Made at bridge below dam.

Daily gage height, in feet, of North Fork of Shenandoah River near Riverton, Va., for 1906.

[L. W. Burke, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	5.7	5.8	4.55	7.9	5.65	4.62	5.05
2	5.45	5.2	4.5	7.1	5.5	4.7	4.88
3	5.4	5.1	4.75	6.7	5.4	4.58	4.85
4	8.6	5.5	6.45	6.32	5.35	4.52	6.12
5	7.75	5.0	6.55	6.1	5.25	4.65	5.52
6	6.83	4.98	5.9	5.92	5.32	4.62	5.2
7	6.2	5.15	5.55	5.75	5.32	4.55	4.95
8	5.85	5.6	5.45	5.6	5.48	4.75	4.82
9	5.58	5.5	5.35	5.52	5.45	4.62	4.7
10	5.35	5.25	5.25	6.1	5.3	4.6	4.6
11	5.37	5.45	5.15	5.95	5.22	4.85	4.6
12	5.27	4.9	5.0	5.75	5.2	4.78	4.6
13	5.25	4.68	5.0	5.62	5.05	4.65	4.65
14	5.3	4.6	5.0	5.28	5.0	4.58	4.62
15	5.4	4.68	5.05	6.4	4.9	5.05	....
16	5.48	4.65	5.2	6.98	4.88	5.25	....
17	5.4	4.8	5.45	6.4	4.82	5.5	....
18	5.38	4.55	5.58	6.05	4.8	5.85	....
19	5.33	4.52	5.8	5.88	4.8	5.9	....
20	5.27	4.6	5.9	5.7	4.72	5.65	....
21	5.2	4.6	5.95	5.58	4.62	6.85	....
22	5.1	4.6	6.2	5.48	4.6	7.25	....
23	5.05	4.6	6.55	5.4	4.6	6.6	....
24	5.7	4.6	6.45	5.28	4.55	5.8	....
25	5.9	4.53	6.2	5.2	4.55	5.55	....
26	5.55	4.55	6.1	5.2	4.52	5.8	....
27	5.33	4.52	7.5	7.48	4.52	6.1	....
28	5.3	4.58	9.4	6.7	5.08	6.2	....
29	5.37	....	8.45	6.15	4.9	5.7	....
30	5.43	....	8.35	5.85	4.75	5.35	....
31	5.35	....	8.1	....	4.65	....	....

NOTE.—Backwater due to ice Feb. 4, 7-11, 17.

Daily discharge, in second-feet, of North Fork of Shenandoah River near Riverton, Va., for 1906.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1	1,000	720	300	3,210	962	335	565
2	820	655	275	2,270	855	375	469
3	785	595	400	1,870	785	315	452
4	4,160	565	1,632	1,513	752	285	1,337
5	3,020	535	1,728	1,320	688	350	869
6	2,000	524	1,155	1,171	738	335	655
7	1,405	502	890	1,088	738	300	508
8	1,115	502	820	925	841	400	436
9	911	502	752	869	820	335	375
10	752	502	688	1,320	720	325	325
11	766	502	625	1,195	668	452	325
12	700	480	535	1,088	655	415	325
13	688	365	535	940	565	350	350
14	720	325	535	707	535	315	335
15	785	365	565	1,585	480	565	....

Daily discharge, in second-feet, of North Fork of Shenandoah River near Riverton, Va., for 1906—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
16	841	350	655	2,150	469	687	......
17	785	325	820	1,585	436	855	......
18	772	300	911	1,278	425	1,115	......
19	740	285	1,075	1,139	425	1,155	......
20	700	325	1,155	1,000	385	962	......
21	655	325	1,195	911	335	2,020	......
22	595	325	1,405	841	325	2,435	......
23	565	325	1,728	785	325	1,775	......
24	1,000	325	1,632	707	300	1,075	......
25	1,155	290	1,405	655	300	890	......
26	890	300	1,820	655	285	720	......
27	740	285	2,720	2,696	285	1,320	......
28	720	315	5,350	1,870	583	1,405	......
29	766	......	3,960	1,862	480	1,000	......
30	806	......	3,810	1,115	400	752	......
31	752	......	3,470	......	350	......	......

NOTE.—Backwater, discharge estimated, Feb. 4, 7-11, and 17. Discharge computed from a rating curve well defined between 100 and 855 second-feet.

Monthly discharge of North Fork of Shenandoah River near Riverton Va., for 1899–1906.

[Drainage area, 1,040 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1899					
June 26-30	307	255	298	0.282	0.052
July	481	130	228	.220	.254
August	390	151	220	.212	.244
September	355	140	227	.219	.244
October	225	140	185	.178	.205
November	545	168	238	.230	.257
December	390	140	255	.246	.284
1900					
January	4,330	255	702	.677	.780
February	3,862	355	1,128	1.09	1.14
March	5,700	585	1,620	1.56	1.80
April	1,760	465	765	.738	.823
May	585	225	324	.812	.360
June	2,195	195	504	.486	.542
July	1,616	140	294	.284	.327
August	207	90	128	.123	.142
September	355	130	155	.149	.166
October	320	168	219	.211	.243
November	3,890	140	441	.425	.474
December	2,650	140	548	.528	.609
The year	5,700	90	569	.549	7.41

Monthly discharge of North Fork of Shenandoah River near Riverton Va., for 1899–1906—Continued.

Month	Discharge in second-feet: Maximum	Minimum	Mean	Per square mile	Run-off (depth in inches on drainage area)
1901					
January	2,195	195	627	.605	.698
February	390	207	299	.288	.300
March	10,960	195	1,391	1.34	1.54
April	21,630	693	4,034	3.89	4.34
May	17,850	728	2,653	2.56	2.95
June	12,680	990	2,842	2.74	3.06
July	4,030	505	1,499	1.44	1.66
August	2,260	428	862	.831	.958
September	2,390	168	684	.660	.736
October	1,322	195	396	.382	.440
November	1,580	140	363	.350	.390
December	14,580	268	3,091	2.98	3.44
The year	21,630	140	1,562	1.50	20.51
1902					
January	3,960	545	1,304	1.26	1.45
February 1-25	6,660	1,090	1,969	1.90	1.77
March	....	....	....	....	....
April	....	....	....	....	....
May	....	....	....	....	....
June	....	....	....	....	....
July	....	....	....	....	....
August 16-31	275	220	243	.234	.139
September	318	165	211	.204	.228
October	440	220	259	.250	.288
November	800	190	317	.306	.341
December	3,890	495	1,228	1.18	1.36
1903					
January 1-28	8,390	495	2,225	2.15	2.24
February 9-28	3,205	735	1,127	1.09	.811
March	6,860	670	1,750	1.69	1.95
April	6,605	735	1,848	1.78	1.99
May	1,340	390	549	.529	.610
June	10,360	580	2,208	2.13	2.38
July	1,840	340	736	.710	.819
August	800	255	371	.358	.413
September	1,655	295	464	.447	.499
October	640	275	373	.360	.415
November	295	255	265	.256	.286
December	522	255	284	.274	.316
1904					
January 1-23	255	255	255	.246	.210
February	....	....	....	....	....
March 5 31	1,610	400	620	.598	.600
April	2,465	318	661	.637	.711
May	1,840	440	718	.692	.798
June	2,090	318	606	.584	.652
July	2,212	295	554	.534	.616
August	550	125	255	.246	.284
September	172	96	124	.120	.134
October	125	90	110	.106	.122
November	125	100	112	.108	.120
December	350	105	225	.217	.250

Monthly discharge of North Fork of Shenandoah River near Riverton Va., for 1899–1906—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)
	Maximum	Minimum	Mean	Per square mile	
1905					
January 1-7, 23-31	1,155	155	759	.732	.436
February	855	855	855	.824	.858
March	2,900	785	1,335	1.29	1.49
April	1,075	375	596	.575	.642
May	1,362	230	406	.392	.452
June	7,450	155	1,042	1.00	1.12
July	2,270	400	908	.876	1.01
August	1,320	198	417	.402	.464
September	252	140	192	.185	.206
October	275	112	170	.164	.189
November	230	125	172	.166	.185
December	5,575	140	889	.857	.988
1906					
January	4,160	565	1,036	.996	1.15
February	720	285	418	.402	.419
March	5,850	275	1,421	1.37	1.58
April	3,210	655	1,324	1.27	1.42
May	962	285	545	.524	.604
June	2,435	285	787	.757	.845
July 1-14	1,337	325	528	.508	.262

NOTE.—Drainage area of 1,037 square miles used previous to 1906. River frozen and no correction made in discharge estimates for following periods: Dec. 26-31, 1899; Jan. 1-14, Jan. 30 to Feb. 6, 1900; part of January and February, 1901; Dec. 21-28, 1901; Feb. 4-24, 1902; Jan. 12-28, Dec. 16-23, 26-31, 1903; Jan. 1-23, Dec. 12-26, 1904; Jan. 5 to Mar. 4, 1905. Backwater caused by ice Feb. 4, 7-11, and 17, 1905, and discharge estimates corrected.

PASSAGE CREEK AT BUCKTON, VA.

Location.—At the trestle of the Southern Railway at Buckton, a siding about a mile east of Waterlick, and about 700 feet above the mouth.

Drainage area.—Not measured.

Records available.—October 26, 1905, to July 15, 1906.

Gage.—Vertical staff fastened to third trestle bent from left abutment.

Discharge measurements.—Made from the railway trestle.

Channel and control.—Banks below the bridge are low and likely to overflow. The fall to the mouth of the creek is 6 or 8 feet.

Extremes of stage.—Maximum stage recorded: 4.4 feet, morning of June 18, 1906. Minimum stage recorded: 0.75 foot, May 26, 1906.

Winter flow.—Ice forms in the stream and probably affects discharge relation.

Measurements insufficient for computations of discharge.

Discharge measurements of Passage Creek at Buckton, Va., in 1905–6.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1905				1906			
Oct. 26....	Robert Follansbee ..	1.23	40.5	Apr. 13 ..	Robert Follansbee ..	1.40	91
Dec. 27....	.....do	1.25	50.0	June 16 ..	.....do	1.72	1.32

Daily gage height, in feet, of Passage Creek at Buckton, Va., for 1905–6.

[Nehemiah Messick, observer.]

Day	Oct.	Nov.	Dec.	Day	Oct.	Nov.	Dec.	Day	Oct.	Nov.	Dec.
1905				1905				1905			
1	......	0.95	0.9	11	......	.95	.95	21	......	.9	3.15
2	......	.9	.9	12	......	.85	.9	22	......	.9	3.1
3	......	.95	.95	13	......	.9	.95	23	......	.9	2.35
4	......	.9	1.4	14	......	.85	.9	24	......	.85	2.0
5	......	.95	1.2	15	......	.9	.95	25	......	.9	1.95
6	......	.95	1.2	16	......	.95	1.15	26	1.2	.9	1.45
7	......	.9	1.1	17	......	.85	1.1	27	1.15	.85	1.4
8	......	.95	1.15	18	......	.9	1.15	28	1.15	.9	1.25
9	......	.9	.95	19	......	.85	1.1	29	.9	.85	2.2
10	......	.95	.95	20	......	.95	1.15	30	.95	.95	1.8
								31	.95	......	1.4

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	1.4	1.2	1.1	2.6	1.3	0.85	1.3
2	1.35	1.25	1.0	2.2	1.3	.95	1.2
3	1.3	1.3	1.1	1.9	1.3	.9	1.2
4	3.4	1.3	3.1	1.8	1.25	.85	1.2
5	2.0	1.3	2.2	1.7	1.25	.9	1.1
6	1.8	1.4	1.6	1.6	1.25	1.1	1.0
7	1.5	1.4	1.5	1.6	1.25	1.0	.9
8	1.5	1.6	1.5	1.5	1.3	.9	.9
9	1.5	1.7	1.5	1.3	1.25	.85	.85
10	1.55	1.6	1.4	1.9	1.2	.85	.85
11	1.55	1.5	1.3	1.6	1.2	.85	.85
12	1.5	1.5	1.3	1.5	1.2	1.1	.8
13	1.4	1.2	1.3	1.4	1.2	1.0	1.0
14	1.4	1.1	1.3	1.4	1.2	.9	.85
15	1.5	1.1	1.4	2.5	1.1	.9	.85
16	1.45	1.2	1.4	2.4	1.1	1.6	......
17	1.4	1.15	1.35	2.0	1.0	2.55	......
18	1.3	1.15	1.4	1.85	1.0	3.2	......
19	1.3	1.1	1.6	1.7	1.0	2.2	......
20	1.3	1.1	1.5	1.6	1.0	2.1	......
21	1.2	1.0	1.6	1.55	1.0	2.4	......
22	1.2	1.0	1.8	1.5	.95	2.52	......
23	1.2	1.0	2.2	1.4	.9	2.1	......
24	1.25	1.0	2.1	1.4	.9	1.95	......
25	1.2	1.0	2.1	1.4	.8	1.9	......
26	1.2	1.0	2.1	1.4	.75	1.7	......
27	1.2	1.0	2.6	1.65	.8	2.6	......
28	1.25	1.1	3.4	1.5	.95	1.7	......
29	1.2	......	3.4	1.4	1.0	1.6	......
30	1.2	......	3.3	1.35	.9	1.4	......
31	1.2	......	2.6	......	.85	......	......

NOTE.—Stream frozen Dec. 17-19, 1905, and Feb. 4 to 13, 1906.

GOOSE CREEK NEAR LEESBURG, VA.

Location.—At Evergreen Mills about 7 miles directly south of Leesburg, about 1 mile below the mouth of Little River, and 10 miles above the mouth of Goose Creek.

Drainage area.—338 square miles.

Records available.—July 12, 1909, to December 31, 1912.

Gage.—Vertical staff, read once daily, spiked to a tree on the left bank immediately below the tailrace of the mill.

Discharge measurements.—Made between the mill and the dam, either by wading or from the highway bridge. The discharge of the mill race is also measured and added to the discharge between the mill and the dam.

Channel and control.—Left bank overflows at stage of about 10 feet. Stream is wider below than at gage and slope is flat. Control section not examined, but the plotting of the discharge measurements indicates that it is not permanent.

Extremes of discharge.—On September 24 and 25, 1912, water was above the gage, which reads to 16.0 feet. The discharge for 16 feet has been estimated at 7,000 second-feet. Minimum recorded stage was 0.06 foot, October 5, 1910; corresponding discharge, 1.6 second-feet. The extremes of discharge may be subject to large errors because of lack of discharge measurements at those stages.

Winter flow.—Ice forms at the gage but seldom entirely across the stream. The effect on the discharge relation is not accurately known as the station was not inspected during any periods when ice was present.

Regulation.—The dam at this point is of timber and rock, and at low stages most of the water passes through it. The mill race carries water at all times, three or four times more when the mill is running than when it is idle. This variation in flow causes variation in the gage heights ranging from a few hundredths to about 0.15 foot; but as the mill is run only four or five hours a day the fluctuation has a relatively small effect on the accuracy of estimates.

Accuracy.—Because of the few discharge measurements only fairly well-defined rating curves have been developed. The gage-height record has not been entirely satisfactory at times. The results can be considered only fair for ordinary stages, and poor at extreme high and low stages.

Discharge measurements of Goose Creek near Leesburg, Va., in 1909–1915.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1909				1911			
July 19....	G. C. Stevens.......	0.83	[a] 53.2	Oct. 6....	J. G. Mathers.......	.94	[e] 68
Aug. 19...	.....do................	.97	[b] 81.7				
1910				1913			
Jan. 22 ...	G. C. Stevens......	4.42	[c] 1,330	July 16...	Batchelder and Walters	.68	[f] 40.5
Jan. 25 ...	.....do	2.23	[d] 451	1915			
Jan. 25 ...	.....do	2.16	[d] 447	June 18 ..	G. C. Stevens......	2.34	[g] 368

[a] Left channel, 5.8 second-feet; right channel, 39.3 second-feet; mill race, mill not running, 8.1 second-feet.
[b] Left channel, 6.1 second feet; right channel, 44.4 second-feet; mill race, mill running, 31.2 second-feet.
[c] Includes 40 second-feet; estimated quantity flowing in mill race.
[d] Includes 28.0 second-feet flowing in mill race.
[e] Includes 11.2 second-feet flowing in mill race.
[f] Includes 5.4 second-feet, leakage into tailrace; mill not running.
[g] Includes 12.2 second-feet, leakage into tailrace; mill not running.

Daily gage height, in feet, of Goose Creek near Leesburg, Va., for 1909–1912.

[J. O. Daniel, observer.]

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909							1909						
1	......	0.75	0.64	0.80	1.25	1.20	16	1.05	.92	.92	1.08	1.50	1.60
2	......	.78	.62	.78	1.26	1.10	17	1.05	3.00	.98	1.04	1.40	1.84
3	......	.80	.64	.78	1.28	1.08	18	1.02	1.10	1.05	1.00	1.85	1.32
4	......	.83	.70	.76	1.36	1.10	19	1.00	1.00	.95	1.00	1.40	1.10
5	......	.76	.75	.85	1.40	1.06	20	.95	.90	.90	1.00	1.40	1.10
6	......	.75	.74	.75	1.35	1.08	21	.85	.86	.85	.98	1.85	1.08
7	......	.80	.75	.66	1.30	1.10	22	.84	.84	.80	1.20	1.40	1.06
8	......	.80	.72	.65	1.45	1.12	23	.80	.82	.82	1.00	1.50	1.08
9	......	.82	.74	.64	1.35	1.08	24	.80	.76	1.10	1.20	1.20	1.10
10	......	.85	1.00	.64	1.45	1.12	25	.82	.74	1.00	1.40	1.10	1.10
11	......	.78	1.20	.62	1.50	1.10	26	.80	.70	.96	1.30	1.15	1.06
12	1.08	.79	1.10	.80	1.40	1.20	27	.80	.66	.92	1.38	1.10	1.08
13	1.05	.76	1.00	1.40	1.35	2.00	28	.80	.66	.88	1.30	1.08	1.08
14	1.02	.75	.90	1.25	1.40	4.00	29	.80	.62	.85	1.35	1.10	1.10
15	1.02	.85	.88	1.15	1.45	3.00	30	.79	.60	.82	1.38	1.15	1.10
							31	.81	.60	......	1.30	......	1.08

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
1	1.08	1.60	4.60	1.10	1.54	1.06	1.28	0.70	0.42	0.10	0.70	0.95
2	1.10	1.58	3.10	1.00	1.40	1.04	1.30	.65	.48	.12	.65	.95
3	1.10	1.50	2.85	1.05	1.38	1.10	1.24	.60	.50	.10	.70	.94
4	1.08	1.95	2.36	1.10	1.55	1.20	1.48	.65	.60	.08	.68	.95
5	1.10	1.85	2.25	1.30	1.35	1.30	1.50	.62	.70	.06	.70	1.00
6	1.10	1.90	2.20	1.30	1.30	1.40	1.28	.64	.66	.10	.65	1.10
7	3.30	1.98	2.05	1.20	1.28	1.38	1.15	.66	.65	.12	.70	1.10
8	2.00	1.52	2.02	1.20	1.10	1.36	1.22	.68	.62	.14	.68	1.05
9	1.80	1.50	1.95	1.20	1.02	1.30	1.35	.55	.60	.20	.70	1.05
10	1.30	1.50	1.90	1.15	.95	2.00	1.34	.60	.61	.40	.75	1.05
11	1.25	1.45	1.85	1.15	.94	2.40	1.30	.65	.62	.50	.77	1.05
12	1.10	1.50	1.88	1.10	1.30	3.00	1.88	.68	.65	.45	.75	1.05
13	1.10	1.30	1.82	1.08	1.32	2.65	2.06	.70	.66	.40	.72	1.05
14	1.08	1.32	1.73	1.05	1.28	2.10	1.38	.65	.60	.45	.75	1.05
15	1.10	3.30	1.64	1.05	1.15	1.80	1.12	.64	.50	.40	.70	1.10
16	1.15	4.50	1.55	1.08	1.12	6.00	1.10	.80	.40	.40	.75	1.10
17	1.20	4.51	1.50	2.00	1.10	3.08	1.05	.92	.30	.45	.85	1.10
18	1.25	6.51	1.40	2.70	1.08	3.02	1.04	.95	.25	.40	.86	1.10
19	7.00	3.40	1.38	2.50	1.04	3.00	1.06	.96	.20	.38	.90	1.10
20	3.00	3.35	1.39	2.00	1.02	2.30	1.10	.94	.20	.40	.88	1.10
21	6.00	3.25	1.38	1.90	1.04	2.10	1.05	.82	.22	.50	.85	1.10
22	4.70	3.87	1.38	1.80	1.06	2.04	.98	.75	.20	.70	.90	1.00
23	3.75	3.52	1.37	1.54	1.20	1.85	1.00	.70	.18	1.00	.92	1.05
24	3.05	2.90	1.32	2.36	1.12	1.74	.98	.65	.15	1.50	.95	1.05
25	2.20	2.71	1.32	3.00	1.44	1.50	.94	.62	.14	1.10	1.10	1.10
26	1.80	2.67	1.33	2.50	1.30	1.45	.90	.64	.12	.95	.98	1.10
27	1.70	3.70	1.33	2.20	1.22	1.38	.92	.55	.13	.75	1.00	1.15
28	1.70	4.10	1.32	1.90	1.10	2.15	.90	.50	.15	.70	1.05	1.25
29	1.68	....	1.30	1.60	1.12	1.85	.88	.48	.10	.65	1.08	1.25
30	1.75	....	1.24	1.55	1.10	1.48	.80	.40	.12	.70	1.00	1.90
31	1.70	....	1.20	....	1.08	....	.75	.38	....	.60	....	1.90

Daily gage height, in feet, of Goose Creek near Leesburg, Va., for 1909–1912—Contd.

Day	Jan.	Feb.	Mar.	Apr.	Sept.	Oct.	Nov.	Dec.
1911								
1	1.55	2.6	1.6	1.6	2.1	1.0	1.2	2.05
2	1.8	2.35	1.6	1.45	2.1	1.05	1.24	2.08
3	2.6	2.2	1.6	1.45	2.2	1.1	1.28	1.96
4	2.8	2.5	1.6	1.7	3.0	1.08	1.32	1.9
5	2.0	2.0	1.4	3.45	3.5	1.05	1.3	1.85
6	2.0	1.9	1.85	2.7	4.0	1.02	1.3	1.84
7	2.0	1.8	1.85	2.4	3.0	1.03	1.4	1.5
8	1.85	1.8	1.85	2.4	2.0	1.08	1.5	1.46
9	1.8	1.75	1.4	2.3	.6	1.06	2.0	1.45
10	1.7	1.75	1.7	2.0	1.5	1.08	1.8	1.4
11	1.6	1.7	2.0	2.0	1.5	1.1	1.6	1.38
12	1.05	1.75	2.6	1.9	2.0	1.08	1.5	1.4
13	1.35	1.7	2.75	1.85	2.6	1.08	3.0	1.36
14	1.9	1.7	2.5	1.85	2.6	1.06	2.8	1.3
15	1.2	1.75	2.4	1.85	2.6	1.08	2.75	1.28
16	1.3	1.7	2.2	1.7	2.5	1.1	2.9	1.35
17	1.4	1.7	2.5	1.7	2.5	1.04	2.88	1.5
18	1.35	1.65	2.5	1.65	2.25	4.0	3.0	1.6
19	1.35	1.7	2.0	1.65	2.0	3.0	3.0	1.8
20	1.2	1.7	2.0	1.65	2.0	2.0	2.8	2.0
21	1.15	1.7	2.0	1.65	1.7	1.8	2.75	2.05
22	1.15	1.7	1.9	1.65	1.0	1.65	2.5	2.3
23	1.2	1.65	1.85	1.6	1.8	1.8	2.45	3.0
24	1.5	1.65	1.7	1.6	1.1	1.85	2.4	3.2
25	1.55	1.65	1.65	1.55	1.05	1.82	2.55	3.4
26	1.55	1.65	1.65	1.4	1.05	1.78	2.2	3.5
27	1.6	1.65	1.65	1.4	1.0	1.76	2.18	4.0
28	1.6	1.65	1.8	1.4	1.0	1.74	2.0	3.8
29	2.3	....	2.0	1.4	1.05	1.4	1.98	3.4
30	3.5	....	2.5	1.35	1.0	1.38	2.1	3.0
31	2.9	....	1.6	....	....	1.3	....	2.8

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	3.5	1.6	3.6	3.8	2.4	2.6	2.2	2.7	1.0	2.9	1.3	1.2
2	3.4	1.6	3.5	3.4	2.4	2.8	2.15	2.7	.75	2.8	1.3	1.22
3	3.4	1.55	3.0	3.6	2.4	2.8	2.1	2.9	.6	2.8	1.3	1.22
4	3.4	1.55	2.8	3.2	2.5	2.7	2.05	2.8	.6	2.8	1.3	1.2
5	3.2	1.5	2.6	3.1	2.5	2.5	2.15	2.8	.6	2.5	1.28	1.3
6	3.2	1.5	2.5	2.8	2.5	3.3	2.1	3.0	.75	2.2	1.28	1.3
7	3.0	1.5	2.8	3.2	2.6	2.7	2.0	2.9	1.2	2.0	1.27	1.3
8	2.8	1.48	2.8	2.8	2.8	2.6	1.8	2.8	1.6	1.75	1.25	1.28
9	2.6	1.48	2.6	2.3	2.7	2.6	1.4	2.8	1.5	1.3	1.25	1.28
10	2.4	1.46	2.6	2.4	2.7	2.6	1.2	2.4	1.0	1.3	1.26	1.26
11	2.15	1.5	2.6	2.35	4.0	2.5	1.0	2.2	.8	1.3	1.26	1.2
12	2.1	1.5	3.0	2.45	4.5	2.4	1.1	2.0	.6	1.3	1.26	1.2
13	2.05	1.48	4.5	2.3	5.0	2.4	1.2	1.9	.4	1.3	1.26	1.2
14	2.05	1.46	4.0	2.2	5.5	2.4	1.4	1.8	.3	1.3	1.26	1.2
15	2.0	1.46	5.5	2.1	4.0	2.5	1.4	2.0	.3	1.3	1.26	1.2
16	2.0	1.48	4.6	2.1	3.8	3.0	1.5	1.8	.3	1.3	1.26	1.4
17	1.85	1.5	4.0	2.2	4.0	3.5	1.6	1.4	.3	1.3	1.26	1.4
18	1.8	1.6	3.5	2.4	3.3	2.9	1.65	1.3	.5	1.3	1.26	1.38
19	1.8	1.6	2.8	2.5	5.0	3.1	1.65	1.2	2.1	1.3	1.26	1.36
20	1.85	2.5	2.6	2.6	4.8	3.2	1.65	1.0	2.1	1.3	1.26	1.35

Daily gage height, in feet, of Goose Creek near Leesburg, Va., for 1909–1912—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
21	1.8	2.7	2.3	2.5	4.2	3.1	1.65	.95	2.2	1.3	1.26	1.35
22	1.8	3.0	2.6	2.5	3.4	3.0	1.7	.95	2.2	1.3	1.26	1.35
23	1.8	4.5	2.8	2.5	3.2	3.0	1.7	1.0	3.0	1.25	1.26	1.35
24	1.7	4.0	2.9	2.45	2.7	2.8	2.1	.85	....	1.25	1.24	1.38
25	1.7	3.5	2.7	2.4	2.5	2.8	2.0	.85	....	1.25	1.24	1.4
26	1.7	3.6	2.7	2.5	2.4	2.7	1.8	.85	5.0	1.25	1.23	1.45
27	1.65	5.0	2.5	2.4	2.4	2.6	1.7	1.0	4.0	1.3	1.22	1.5
28	1.65	4.0	2.45	2.6	2.6	2.5	1.7	1.2	3.0	1.3	1.2	1.5
29	1.65	3.8	6.0	2.5	2.8	2.2	1.7	1.2	3.0	1.3	1.2	1.5
30	1.65	....	4.5	2.5	2.7	2.25	1.9	1.2	3.0	1.3	1.2	3.5
31	1.65	....	3.0	....	2.7	....	2.8	1.2	....	1.3	....	5.0

NOTE.—1909: Creek frozen Dec. 20-31; maximum thickness of ice, Dec. 25-31, 4 inches.

1910: Discharge relation probably affected by ice from about Jan. 1-6 and 12-18, for short periods during first half of February, and from about Dec. 5-24.

1911: Discharge relation probably affected by ice for a considerable part of January and February. It is not known whether gage heights were read to water surface or to top of ice. The lower part of the gage became covered with silt during 1911, and for that reason the gage heights reported for May to August were considered too unreliable to publish. Silt was cleared away Oct. 6.

1912: Discharge relation affected by ice during parts of January and February. On Sept. 24 and 25 water was above the gage, which reads to 16.0 feet.

Daily discharge, in second-feet, of Goose Creek near Leesburg, Va., for 1909–1912.

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909							**1909**						
1	......	42	29	49	142	130	16	95	69	69	102	210	240
2	......	46	27	46	145	106	17	95	743	80	93	182	166
3	......	49	29	46	150	102	18	88	106	95	84	168	160
4	......	54	36	44	171	106	19	84	84	74	84	182	106
5	......	44	42	57	182	97	20	74	65	65	84	182	90
6	......	42	41	42	168	102	21	57	59	57	80	168	80
7	......	49	42	32	155	106	22	55	55	49	130	182	80
8	......	49	39	30	196	111	23	49	52	52	84	210	70
9	......	52	41	29	168	102	24	49	44	106	130	130	60
10	......	57	34	29	196	111	25	52	41	84	182	106	60
11	......	46	130	27	210	106	26	49	36	76	155	118	50
12	91	48	106	49	182	130	27	49	32	69	177	106	50
13	95	44	84	182	168	870	28	49	32	62	155	102	50
14	88	42	65	142	182	1,150	29	49	27	57	168	106	40
15	88	57	62	118	196	743	30	48	25	52	177	118	40
							31	51	25	......	155	......	40

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
1	....	240	1,410	106	222	97	150	36	12	2.0	36	74
2	....	234	783	84	182	93	155	30	16	2.4	30	74
3	....	210	684	95	177	106	140	25	17	2.0	36	73
4	....	353	499	106	225	130	204	30	25	1.8	34	74
5	....	320	459	155	168	155	210	27	36	1.6	36	....

Daily discharge, in second-feet, of Goose Creek near Leesburg, Va., for 1909–1912—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
6	....	336	441	155	155	182	150	29	32	2.0	30	....
7	863	363	388	130	150	177	118	32	30	2.4	36	....
8	370	216	377	130	106	171	135	34	27	2.8	34	....
9	303	210	353	130	88	155	168	21	25	4.0	36	....
10	155	210	336	118	74	370	166	25	26	11	42	....
11	142	196	320	118	78	513	155	30	27	17	45	....
12	106	210	320	106	155	743	329	34	30	14	42	....
13	106	155	310	102	160	607	391	36	32	11	39	....
14	102	160	281	95	150	405	177	30	25	14	42	....
15	106	863	252	95	118	303	111	29	17	11	36	....
16	118	1,370	225	102	111	2,040	106	49	11	11	42	....
17	130	1,370	210	370	106	775	95	69	7.0	14	57	....
18	142	2,270	182	626	102	751	93	74	5.5	11	59	....
19	2,490	903	177	550	93	743	97	76	4.0	10	65	....
20	743	883	179	370	88	477	106	78	4.0	11	62	....
21	2,040	843	177	336	93	405	95	52	4.6	17	57	....
22	1,460	1,100	177	303	97	384	80	42	4.0	36	65	....
23	1.050	962	174	222	130	320	84	36	3.6	84	69	....
24	763	704	160	499	111	284	80	30	3.0	210	74	....
25	441	630	160	743	193	210	73	27	2.8	106	106	106
26	303	615	163	550	155	196	65	29	2.4	74	80	106
27	271	1,030	163	441	135	177	69	21	2.6	42	84	118
28	271	1,200	160	336	106	423	65	17	3.0	36	95	142
29	265	....	155	240	111	320	62	16	2.0	30	102	142
30	287	....	140	225	106	204	49	11	2.4	36	84	336
31	271	....	130	....	102	....	42	10	....	25	....	336

Day	Jan.	Feb.	Mar.	Apr.	Sept.	Oct.	Nov.	Dec.
1911								
1	225	588	240	240	405	84	130	388
2	303	495	240	196	405	95	140	398
3	588	441	240	196	441	106	150	356
4	665	550	240	271	743	102	160	336
5	370	370	182	924	944	95	155	320
6	370	336	168	626	1,150	88	155	316
7	370	303	168	513	743	91	182	210
8	320	303	168	513	370	91	210	199
9	303	287	182	477	25	97	370	196
10	271	287	271	370	210	102	303	182
11	240	271	370	370	210	106	240	177
12	95	287	588	336	370	102	210	182
13	168	271	646	320	588	102	743	171
14	336	271	550	320	588	97	665	155
15	130	287	513	320	588	102	646	150
16	155	271	441	271	550	106	704	168
17	182	271	550	271	550	93	696	210
18	168	256	550	256	459	1,150	743	240
19	168	271	370	256	370	743	743	303
20	130	271	370	256	370	370	665	370
21	118	271	370	256	271	303	646	388
22	118	271	336	256	84	256	550	477
23	130	256	320	240	303	303	532	743
24	210	256	271	240	106	320	513	823
25	225	256	256	225	95	310	569	903
26	225	256	256	182	95	297	441	944
27	240	256	256	182	84	290	434	1,150
28	240	256	303	182	84	284	370	1,070
29	477	....	370	182	95	182	363	903
30	944	....	550	168	84	177	405	743
31	704	....	240	....	....	155	....	665

Daily discharge, in second-feet, of Goose Creek near Leesburg, Va., for 1909–1912—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	944	240	985	1,070	513	588	441	626	84	704	155	130
2	903	240	944	903	513	665	423	626	42	665	155	135
3	903	225	743	985	513	665	405	704	25	665	155	185
4	903	225	665	823	550	626	388	665	25	665	155	130
5	823	210	588	783	550	550	423	665	25	550	150	155
6	823	210	550	665	550	863	405	743	42	441	150	155
7	743	210	665	823	588	626	370	704	130	370	148	155
8	665	204	665	665	665	588	303	665	240	287	142	150
9	588	204	588	477	626	588	182	665	210	155	142	150
10	513	199	588	513	626	588	130	513	84	155	145	145
11	423	210	588	495	1,150	550	84	441	49	155	145	130
12	405	210	743	532	1,370	513	106	370	25	155	145	130
13	388	204	1,370	477	1,590	513	130	336	11	155	145	130
14	388	199	1,150	441	1,820	513	182	303	7	155	145	130
15	370	199	1,820	405	1,150	550	182	370	7	155	145	130
16	370	204	1,410	405	1,070	743	210	303	7	155	145	182
17	320	210	1,150	441	1,150	944	240	182	7	155	145	182
18	303	240	944	513	863	704	256	155	17	155	145	177
19	303	240	665	550	1,590	783	256	130	405	155	145	171
20	320	550	588	588	1,500	823	256	84	405	155	145	168
21	303	626	477	550	1,240	783	256	74	441	155	145	168
22	303	743	588	550	903	743	271	74	441	155	145	168
23	303	1,370	665	550	823	743	271	84	743	142	145	168
24	271	1,150	704	532	626	665	405	57	7,000	142	140	177
25	271	944	626	513	550	665	370	57	7,000	142	140	182
26	271	985	626	550	513	626	303	57	1,590	142	138	196
27	256	1,590	550	513	513	588	271	84	1,150	155	135	210
28	256	1,150	532	588	588	550	271	130	743	155	130	210
29	256	1,070	2,040	550	665	441	271	130	743	155	130	210
30	256	....	1,370	550	626	459	336	130	743	155	130	3,160
31	256	....	743	....	626	....	665	130	....	155	....	1,590

NOTE.—Discharge, except for periods during which discharge relation was affected by ice, computed from a rating curve fairly well defined between 50 and 1,400 second-feet. Discharge Dec. 20-31, 1909, estimated as given. Mean discharge Jan. 1-6, 1910, estimated at 50 second-feet; Dec. 5-24, 1910, 60 second-feet. Discharge relation probably affected by ice at other periods but no corrections have been made therefor. Discharge Sept. 24 and 25, 1912, when water was over gage, estimated as given.

Monthly discharge of Goose Creek near Leesburg, Va., for 1909–1912.

[Drainage area, 338 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1909						
July 12-31	95	48	67.8	0.201	0.15	B.
August	743	25	71.5	.212	.24	B.
September	130	27	63.5	.188	.21	B.
October	182	27	95.5	.283	.33	B.
November	210	102	163	.482	.54	B.
December	1,150	....	160	.473	.55	C.

Monthly discharge of Goose Creek near Leesburg, Va., for 1909–1912—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1910						
January	2,490	....	439	1.30	1.50	B.
February	2,270	155	648	1.92	2.00	B.
March	1,410	130	321	.950	1.10	B.
April	743	84	255	.754	.84	B.
May	225	78	130	.385	.44	B.
June	2,040	93	397	.117	.13	B.
July	391	42	130	.385	.44	B.
August	76	10	34.8	.103	.12	C.
September	36	2.0	14.6	.043	.05	C.
October	210	1.6	27.5	.081	.09	C.
November	106	30	55.2	.164	.18	B.
December	336	....	89.7	.265	.30	D.
The year	2,490	1.6	208	.615	7.19	
1911						
January	944	95	296	0.876	1.01	C.
February	588	256	318	.926	.96	D.
March	646	168	341	1.01	1.16	B.
April	924	168	314	.929	1.04	B.
September	1,150	25	379	1.12	1.25	B.
October	1,150	84	219	.648	.75	B.
November	743	130	428	1.27	1.42	B.
December	1,150	150	446	1.32	1.52	B.
1912						
January	944	256	465	1.38	1.59	D.
February	1,590	199	492	1.46	1.58	D.
March	2,040	477	849	2.51	2.89	B.
April	1,070	405	600	1.78	1.99	B.
May	1,820	513	859	2.54	2.93	B.
June	944	441	642	1.90	2.12	B.
July	665	84	292	.864	1.00	B.
August	743	57	331	.979	1.13	B.
September	[a] 7,000	7	748	2.21	2.47	D.
October	704	142	254	.751	.87	B.
November	155	130	144	.426	.48	C.
December	3,160	130	304	.899	1.04	B.
The year	7,000	7	498	1.47	20.09	

[a] Estimated.

OCCOQUAN CREEK NEAR OCCOQUAN, VA.

Location.—At Frank Davis's farm, about one mile above Beaverdam Creek, and about 4½ miles upstream from and northwest of Occoquan.

Drainage area.—546 square miles.

Records available.—February 14, 1913, to December 31, 1914.

Gage.—Friez automatic, on left bank, installed April 27, 1913, referred to an inclined staff on left bank about 150 feet upstream; previous to this date a temporary vertical staff on opposite bank.

Discharge measurements.—Made from cable about 75 feet below the automatic gage, or by wading.

Channel and control.—Gravel and large rocks; control practically permanent. Point of zero flow at 0.4 foot gage height.

Extremes of discharge.—Maximum stage recorded 1913-14: 18.16 feet, 8 A. M., April 13, 1913, determined by levels to stake set by observer; discharge, 15,900 second feet. Minimum stage recorded: 1.39, September 13 to 18, 1913; discharge, 9.7 second-feet.

Winter flow.—Discharge relation affected by ice.

Accuracy.—Rating curve well defined. Results excellent except for extreme high and low stages.

Coöperation.—Expense of installation and maintenance borne by Potomac Electric Power Co., of Washington, D. C.

Discharge measurements of Occoquan Creek near Occoquan, Va., in 1913–14.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1913				1914			
May 10	G. C. Stevens	2.62	117	Jan. 4	J. G. Mathers	13.20	8,730
May 27	Stevens and Walters	4.06	517	Jan. 5	....do	9.70	4,580
June 3	G. C. Stevens	3.34	280	Jan. 9	Mathers and Harrington	4.80	623
June 5	M. I. Walters	3.02	208	Jan. 15	Peterson and Walters	2.91	187
June 21	Mathers and Padgett	2.23	60.2	Jan. 26	B. J. Peterson	5.41	1,120
July 7	M. I. Walters	2.14	64.4	Feb. 14 [a]	....do	3.52	256
July 14	Batchelder and Walters	1.96	38.6	Feb. 20 [b]	....do	4.48	598
July 22	C. L. Batchelder	1.94	37.0	Feb. 21 [b]	....do	4.65	647
Aug. 27	J. G. Mathers	1.59	16.8	Mar. 11	Peterson and Morgan	7.28	2,380
				May 6	B. J. Peterson	4.92	874
				Sept. 23	J. H. Morgan	1.60	13.9
				Sept. 24	J. G. Mathers	1.57	15.5

[a] Discharge relation affected by ice. One-fourth channel frozen over at control; complete ice cover below control.
[b] Discharge relation affected by ice. Ice cover on overflow section at control; complete ice cover 100 feet below control.

Daily gage height, in feet, of Occoquan Creek near Occoquan, Va., for 1913–14.

[W. V. Davis and Sadie Bradley, observers.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
1	....	....	3.17	4.0	3.07	....	2.24	1.96	1.63	6.0	2.28	2.52
2	....	....	2.89	3.62	2.96	....	2.17	4.25	1.59	3.21	2.20	2.47
3	....	....	2.75	3.44	2.91	3.35	2.16	2.81	1.55	3.04	2.15	2.43
4	....	....	2.65	3.36	....	....	2.17	2.37	1.52	2.52	2.10	2.40
5	....	....	2.59	3.33	....	3.02	....	2.09	1.50	2.22	2.05	2.33
6	....	....	2.58	3.25	....	....	....	1.98	1.49	2.07	2.00	2.26
7	....	....	2.53	3.07	....	....	2.13	1.91	1.49	1.92	2.00	2.27
8	....	....	2.47	2.99	....	....	2.01	1.86	1.48	1.82	2.00	2.29
9	....	....	2.41	2.91	....	....	1.96	1.85	1.48	1.80	2.10	2.35
10	....	....	2.43	2.87	2.60	....	2.07	1.82	1.45	1.80	3.01	2.35
11	....	....	2.65	2.85	2.55	....	2.05	1.92	1.44	1.79	2.88	2.24
12	....	....	3.44	14.2	2.50	2.57	1.98	2.02	1.41	1.74	2.59	2.19
13	....	....	3.03	16.6	2.49	....	1.99	2.10	1.39	1.83	2.43	2.15
14	....	3.2	11.5	11.3	2.53	....	1.96	2.08	1.39	2.04	2.34	2.13
15	....	2.92	10.2	6.8	2.59	....	1.93	1.99	1.39	1.98	2.23	2.11
16	....	2.91	8.2	8.7	2.65	2.40	1.96	1.90	1.39	1.88	2.60	2.05
17	....	2.88	5.45	9.2	....	....	1.95	1.95	1.39	1.83	5.1	2.07
18	....	2.91	4.55	5.45	....	2.40	1.97	1.90	1.39	1.80	3.64	2.06
19	....	2.87	4.15	4.9	....	2.31	2.00	1.89	1.41	1.82	3.15	2.07
20	....	2.79	4.15	4.15	....	2.26	2.04	1.83	1.45	1.90	2.92	2.06
21	....	2.81	5.1	3.87	....	2.23	2.07	1.78	1.72	2.58	2.74	2.07
22	....	2.88	4.55	3.79	....	2.25	1.93	1.74	4.8	2.34	2.56	2.08
23	....	2.88	3.88	3.69	....	2.29	1.91	1.74	2.94	2.13	2.49	2.08
24	....	2.79	3.59	3.57	....	2.27	1.83	1.74	2.40	2.07	2.38	3.21
25	....	2.69	3.51	3.45	....	2.45	1.90	1.78	2.09	3.79	2.29	3.92
26	....	2.61	3.56	3.33	....	3.41	1.95	1.69	1.94	5.8	2.26	9.6
27	....	2.63	10.0	3.27	4.1	3.11	1.87	1.60	1.82	3.71	2.21	6.0
28	....	2.79	6.8	3.48	....	2.61	1.89	1.59	1.74	3.04	2.23	4.2
29	....	....	4.9	3.37	....	2.45	2.01	1.58	1.71	2.73	2.31	3.69
30	....	....	4.35	3.19	....	2.32	1.88	1.59	1.70	2.51	2.46	3.47
31	....	....	4.45	....	....	....	1.85	1.68	....	2.38	....	3.22
1914												
1	3.11	8.2	4.25	3.71	3.86	2.28	2.86	1.92	2.32	1.50	1.60	1.85
2	3.06	4.85	4.7	4.1	3.61	2.20	2.54	1.84	2.09	1.49	1.61	1.83
3	5.55	4.2	4.4	3.89	3.48	2.24	2.35	....	2.08	1.47	1.62	1.87
4	12.9	3.98	4.8	3.71	3.34	2.27	2.28	1.78	1.99	1.48	1.65	1.88
5	9.3	3.75	5.95	3.45	3.64	2.48	2.44	....	2.28	1.51	1.66	1.94
6	6.4	3.72	5.0	3.30	4.65	2.43	4.55	....	2.09	1.52	1.65	1.99
7	5.15	7.4	4.7	3.20	3.76	2.48	4.2	1.78	1.92	1.52	1.63	2.46
8	4.55	5.5	5.75	3.22	3.42	2.43	3.33	....	1.77	1.52	1.64	3.48
9	4.25	4.25	6.5	4.6	3.34	2.23	3.22	....	....	1.53	1.67	3.34
10	4.0	3.89	6.1	3.86	3.37	2.25	2.61	....	....	1.55	1.68	2.88
11	3.68	3.83	7.1	3.48	3.12	2.19	2.78	1.70	1.64	1.56	1.70	2.72
12	3.40	3.65	5.3	3.28	3.06	2.11	2.73	1.99	....	1.56	1.69	2.88
13	3.08	3.26	4.85	3.16	2.93	2.05	2.51	2.54	....	1.57	1.70	2.89
14	3.15	3.49	5.45	3.03	2.98	2.00	4.60	2.38	1.70	1.58	1.71	3.62
15	2.90	3.32	8.45	4.05	3.19	1.99	3.63	2.10	....	1.59	2.09	3.84
16	2.83	3.37	8.4	7.9	2.93	2.01	2.94	2.01	....	1.70	3.02	3.61
17	2.86	3.27	6.9	5.25	2.79	1.99	2.62	1.89	....	1.83	3.23	3.10
18	2.86	3.13	7.3	4.35	2.72	1.97	4.5	....	1.62	2.00	2.65	2.65
19	2.80	3.35	6.0	4.0	2.67	1.92	3.21	....	1.62	2.21	2.37	2.46
20	2.79	4.45	5.0	5.4	2.62	1.97	2.52	....	....	2.04	2.20	2.44
21	2.82	4.6	4.7	7.3	2.61	2.02	2.29	2.33	....	1.92	2.06	2.67
22	2.88	4.2	5.05	4.95	2.63	2.77	2.24	3.20	1.60	1.90	1.95	4.51
23	2.80	4.1	5.4	4.3	2.52	2.49	2.12	2.20	....	1.86	1.88	3.90
24	2.80	3.86	4.85	3.95	2.43	2.65	2.02	1.88	1.57	1.77	1.82	3.39
25	8.1	3.57	4.3	3.75	2.32	2.69	1.99	....	1.62	1.71	1.80	2.99

Daily gage height, in feet, of Occoquan Creek near Occoquan, Va., for 1913–14—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1914												
26	5.6	3.41	4.0	7.4	2.27	2.83	1.99	....	1.64	1.68	1.83	2.76
27	4.45	3.37	3.87	7.6	2.29	2.71	2.38	....	1.60	1.65	1.84	2.70
28	4.1	3.56	3.79	5.0	2.30	4.7	2.18	1.87	1.57	1.66	1.85	2.52
29	3.80	....	3.94	4.35	2.33	6.6	2.03	4.45	1.54	1.65	1.85	2.46
30	3.60	....	3.74	4.2	2.33	3.74	1.95	3.16	1.50	1.62	1.86	2.94
31	5.2	....	3.95	....	2.84	....	1.92	2.69	....	1.60	....	4.8

NOTE.—Temporary staff gage used Feb. 14 to Apr. 26, 1913. Beginning Apr. 27, 1913, records are from automatic gage except for May 27, June 3, 5, 12, 16, and 18, 1913, and Aug. 4, 7, 11, and Sept. 8 to Oct. 11, 1914, when staff gages were read. Discharge relation affected by ice Feb. 11 to Mar. 4, Mar. 8, Dec. 16-19 and 26-29, 1914.

Daily discharge, in second-feet, of Occoquan Creek near Occoquan, Va., for 1913–14.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
1	....	....	241	500	216	360	65	38	19	1,460	70	103
2	....	....	174	371	189	340	57	590	17	252	60	96
3	....	....	144	317	178	290	56	156	15	208	55	90
4	....	....	125	293	170	246	57	81	14	103	50	85
5	....	....	114	284	161	203	56	49	13	62	46	76
6	....	....	113	262	152	175	54	40	13	47	41	67
7	....	....	105	216	143	225	53	35	13	35	41	68
8	....	....	96	196	134	200	42	32	12	29	41	71
9	....	....	86	178	125	175	38	31	12	28	50	78
10	....	....	90	169	116	155	47	29	12	28	200	78
11	....	....	125	165	108	135	46	35	11	27	172	65
12	....	....	317	10,100	100	111	40	43	10	24	114	59
13	....	....	206	13,600	98	104	40	50	9.7	30	90	55
14	....	249	6,570	6,330	105	98	38	44	9.7	45	77	53
15	....	180	5,080	2,080	114	91	36	40	9.7	36	64	51
16	....	178	3,210	3,660	125	85	38	40	9.7	33	116	46
17	....	172	1,200	4,110	115	85	38	38	9.7	30	965	47
18	....	178	718	1,200	135	85	39	34	9.7	28	377	46
19	....	169	552	895	115	73	41	33	10	29	236	47
20	....	152	552	552	115	67	45	30	12	34	180	46
21	....	156	1,000	454	100	64	47	27	23	113	142	47
22	....	172	718	426	115	66	36	24	840	77	110	48
23	....	172	458	392	6,000	71	35	24	185	53	98	48
24	....	152	362	356	13,000	68	30	24	85	47	82	252
25	....	132	338	320	6,000	92	34	24	49	422	71	467
26	....	118	353	284	2,200	308	38	22	37	1,340	67	4,480
27	....	121	4,880	267	535	226	32	17	29	398	61	1,460
28	....	152	2,080	329	700	118	33	17	24	208	64	565
29	....	....	895	296	790	92	42	16	23	140	73	392
30	....	....	630	246	500	75	33	17	22	102	94	326
31	....	....	672	....	430	....	31	21	....	82	....	254
1914												
1	226	3,160	520	398	446	70	167	35	75	13.0	17.0	31
2	213	840	655	530	368	60	106	30	49	12.5	17.5	30
3	1,200	565	585	456	329	65	78	28	44	12.0	18.0	32
4	3,340	488	770	398	287	68	70	27	40	12.5	19.5	33
5	4,180	410	1,430	320	377	97	91	27	70	13.5	20.0	37

Daily discharge, in second-feet, of Occoquan Creek near Occoquan, Va., for 1913–14—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1914												
6	1,730	401	915	275	748	90	702	27	49	14.0	19.5	40
7	990	2,490	770	249	413	97	565	27	35	14.0	18.5	97
8	702	1,170	1,280	254	311	90	284	26	26	14.0	19.0	329
9	582	582	1,800	725	287	64	254	24	24	14.0	20.5	288
10	495	456	1,520	446	296	66	118	23	21	15.0	21.0	172
11	389	420	2,250	329	228	59	150	22	19	15.5	22.0	138
12	305	300	1,060	270	210	51	140	40	20	15.5	21.5	172
13	206	180	840	239	183	46	102	106	21	16.0	22.0	174
14	236	245	1,140	206	194	41	725	82	22	16.0	22.5	389
15	176	210	3,380	512	246	40	374	50	21	16.5	61	445
16	161	215	3,340	2,900	183	42	185	42	20	22.0	213	230
17	167	215	2,100	1,040	152	40	120	33	19	30	261	144
18	167	195	2,410	620	138	39	680	30	18	41	125	106
19	154	230	1,460	495	129	35	252	26	18	61	81	91
20	152	595	915	1,120	120	39	108	22	17	45	60	91
21	158	640	770	2,410	118	43	71	76	17	35	46	132
22	172	505	940	890	121	148	65	249	17	34	38	722
23	154	440	1,120	600	108	98	52	60	16	32	33	466
24	154	315	840	478	90	125	43	33	16	26	29	302
25	3,070	230	600	410	75	132	40	32	18	22.5	28	196
26	1,220	235	495	2,490	68	161	40	32	19	21.0	30	140
27	660	255	450	2,650	71	136	82	32	17	19.5	30	110
28	530	310	422	915	72	770	58	32	16	20.0	31	92
29	425	....	474	620	76	1,870	44	660	15	19.5	31	92
30	365	....	407	565	76	407	38	239	13	18.0	32	189
31	1,020	....	478	....	77	....	35	132	....	17.0	....	338

NOTE.—Discharge determined from a well-defined rating curve, except as follows: May 4-9, June 4, 13-15, and July 5-6, 1913, and for days for which records are lacking during August and September, 1914, interpolated; May 17-26, May 28 to June 2, and June 6-11, 1913, estimated from rainfall records; Feb. 11 to Mar. 4, Mar. 8, Dec. 16-19, 26-29, 1914, when discharge relation was affected by ice, estimated from discharge measurements, climatologic data, and study of automatic gage record. Mean discharge Nov. 15-17, Dec. 7-9, 14-15, 21-23, and 30-31, determined from two-hourly gage heights.

Monthly discharge of Occoquan Creek near Occoquan, Va., for 1913–14.

[Drainage area, 546 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1913						
February 14-28	249	118	164	0.300	0.17	A.
March	6,570	86	1,040	1.90	2.19	A.
April	13,600	165	1,630	2.99	3.34	B.
May	13,000	98	1,070	1.96	2.26	C.
June	360	64	149	.273	.30	B.
July	65	31	42.5	.078	.09	A.
August	590	16	54.9	.101	.12	A.
September	840	9.7	51.9	.095	.11	B.
October	1,540	24	184	.337	.39	A.
November	1,000	41	131	.240	.27	A.
December	4,480	46	315	.577	.67	A.

Monthly discharge of Occoquan Creek near Occoquan, Va., for 1913–14—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1914						
January	8,840	152	926	1.70	1.96	A.
February	3,160	180	582	1.07	1.11	B.
March	3,380	407	1,170	2.14	2.47	A.
April	2,900	206	794	1.45	1.62	A.
May	748	68	213	.390	.45	A.
June	1,870	85	170	.311	.35	A.
July	725	85	188	.344	.40	A.
August	660	22	74.3	.136	.16	B.
September	75	13	26.4	.048	.05	B.
October	61	12.0	21.9	.040	.05	A.
November	261	17.0	46.9	.086	.10	A.
December	838	30	205	.375	.43	A.
The year	8,840	12.0	367	.672	9.15	

NOTE.—See footnotes to tables of daily discharge.

RAPPAHANNOCK RIVER BASIN.

RAPPAHANNOCK RIVER NEAR FREDERICKSBURG, VA.

Location.—About 3½ miles above Fredericksburg, and about 1⅛ miles above the dam of the Spottsylvania Power Co.

Drainage area.—1,590 square miles.

Records available.—September 19, 1907, to December 31, 1914.

Gage.—Vertical staff installed November 4, 1913, to replace chain gage destroyed October 31, 1913. Original gage was a vertical staff, which was destroyed February 14, 1908, and replaced February 20, 1908, by a chain gage under the cable. All three gages were referred to the same datum and the locations were practically the same. Gage read twice daily.

Discharge measurements.—Made from cable at the gage. At extremely low stages measurements can be made by wading or from a bridge over the power canal.

Channel and control.—Both banks wooded; right bank will overflow at stage of about 15 feet, left bank at about 12 feet. One channel, bed composed of bowlders and somewhat rough. Current sluggish at extreme low water. Control is a rocky section a few hundred feet below the gage, and has remained practically permanent.

Extremes of discharge.—Maximum stage recorded 1907-1914: 10.2 feet at 9 a. m., April 13, 1913; discharge, 32,000 second-feet. Minimum stage recorded: 0.30 foot at 3 p. m., August 21, 1914; discharge, 72 second-feet.

Winter flow.—Discharge relation not seriously affected by ice.

Accuracy.—Accurate discharge measurements at low stages are difficult. A rating curve well defined except at extreme low stages has been developed. Estimates of discharge for 1907-1911 as published herewith are revisions of those published by U. S. Geological Survey.

Coöperation.—Station maintained by United States Geological Survey in coöperation with the Spottsylvania Power Co. (formerly the Fredericksburg Power Co.).

Discharge measurements of Rappahannock River near Fredericksburg, Va., in 1907–1915.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1907				1910			
Dec. 7	C. C. Covert	1.78	1,110	Sept. 8	G. C. Stevens	.95	291
Dec. 9	do	1.76	1,060	1911			
1908				July 26 [b]	G. C. Stevens [c]	.70	214
Feb. 20	A. H. Horton	3.98	5,050	1912			
Apr. 29	Follansbee and Barrows	1.57	813	May 13 [d]	J. G. Mathers	9.20	26,700
July 16	R. H. Bolster	1.19	437	1913			
1909				Sept. 3 [b]	G. C. Stevens [c]	.64	166
July 20	G. C. Stevens	1.12	439	Sept. 10	G. C. Stevens [c]	.56	[e] 132
Sept. 8 [a]	Bolster and Stevens	.70	242	1915			
				Jan. 20	G. C. Stevens	3.92	4,970

[a] Canal measured at bridge and river by wading below dam. Discharge probably too high due to increased flow from storage dam.
[b] Made by wading one-half mile below gage.
[c] Assisted by Cecil L. Reid, engineer for Spottsylvania Power Co.
[d] Surface velocities observed and coefficient of 0.85 used to reduce to mean velocity.
[e] Discharge is mean of four measurements of power canal below dam. Entire flow of river was being diverted into power canal.

Daily gage height, in feet, of Rappahannock River near Fredericksburg, Va., for 1907–1914.

[J. W. Franklin, observer.]

Day	Sept.	Oct.	Nov.	Dec.	Day	Sept.	Oct.	Nov.	Dec.	Day	Sept.	Oct.	Nov.	Dec.
1907					1907					1907				
1	......	1.98	1.25	2.10	11	......	1.48	2.28	5.30	21	1.22	1.25	2.22	2.40
2	......	1.82	1.25	2.10	12	......	1.48	1.95	4.00	22	1.22	1.28	2.20	2.30
3	......	1.70	3.28	2.00	13	......	1.45	1.75	3.10	23	2.22	1.25	2.25	3.98
4	......	1.68	2.50	1.90	14	......	1.40	1.68	3.25	24	8.85	1.25	5.50	5.75
5	......	1.65	1.78	1.90	15	......	1.40	1.60	4.72	25	3.30	1.25	5.85	8.80
6	......	1.65	1.65	1.75	16	......	1.35	1.55	3.62	26	2.65	1.22	8.52	3.20
7	......	1.52	1.82	1.75	17	......	1.35	1.55	3.15	27	2.28	1.20	2.95	3.00
8	......	1.55	2.05	1.75	18	......	1.35	1.58	2.92	28	2.10	1.30	2.62	8.00
9	......	1.60	1.72	1.75	19	1.22	1.35	2.35	2.80	29	2.45	1.58	2.42	2.68
10	......	1.52	1.78	2.98	20	1.20	1.30	2.38	2.55	30	2.38	1.42	2.30	2.80
										31	......	1.30	......	3.18

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
1	3.05	2.1	3.2	2.7	1.35	3.35	2.1	2.15	1.8	2.22	2.55	1.5
2	2.48	2.2	3.3	2.55	1.25	2.85	2.3	1.85	1.72	2.15	2.25	1.55
3	2.38	2.1	3.05	2.5	1.65	2.35	2.5	1.72	1.6	2.0	2.1	1.4
4	2.32	2.1	2.9	2.25	1.55	2.8	2.45	1.6	1.55	1.9	2.2	1.5
5	2.30	2.6	2.7	2.18	1.55	3.95	2.45	1.5	1.5	1.8	2.1	1.5
6	2.25	3.0	4.2	2.2	1.65	2.65	2.35	1.4	7.1	1.62	1.9	1.44
7	2.6	2.3	4.3	2.1	2.55	2.35	2.25	1.3	3.2	1.7	1.9	1.82
8	6.6	2.95	3.6	2.1	3.38	2.25	2.1	1.3	2.3	1.6	1.8	1.68
9	3.88	2.7	3.1	2.05	3.35	2.15	1.62	1.45	2.0	1.52	1.7	1.5
10	2.65	2.6	3.15	2.2	2.15	1.95	1.45	1.42	1.9	1.65	1.75	1.55
11	3.85	2.6	3.3	2.22	2.1	2.3	1.35	1.5	1.7	1.78	1.7	1.6
12	8.5	2.88	2.85	2.0	2.05	2.25	1.3	1.35	1.7	2.6	1.68	3.05
13	8.8	3.38	2.8	2.12	1.95	2.05	1.25	1.3	1.52	2.05	1.85	2.72
14	4.82	....	2.62	1.9	1.88	1.95	1.15	1.3	1.42	1.85	1.8	2.0
15	3.9	....	2.4	1.95	1.78	1.85	1.1	1.2	1.45	1.8	1.75	1.78
16	3.52	....	2.48	1.9	1.75	3.85	1.05	1.18	1.3	1.65	2.0	1.78
17	3.25	....	2.4	1.75	1.7	3.45	1.0	1.1	1.35	1.6	2.1	1.75
18	3.0	....	2.5	1.85	1.65	2.75	.9	2.8	1.3	1.6	1.9	1.6
19	2.8	....	2.5	1.95	1.65	2.75	1.1	2.3	1.3	1.55	1.9	1.7
20	2.7	3.95	2.4	2.0	3.8	2.55	1.1	1.6	1.25	1.6	1.85	1.65
21	2.0	3.75	2.2	1.9	4.75	2.3	1.0	1.35	1.3	1.55	1.7	1.5
22	2.55	3.05	2.2	1.8	8.3	2.05	.9	1.25	1.45	1.5	1.75	1.55
23	2.5	3.0	2.35	1.8	4.85	1.95	1.6	1.3	1.5	1.42	1.7	1.55
24	2.4	2.82	2.45	1.6	3.45	2.15	2.2	1.35	1.5	1.4	1.55	1.4
25	2.4	2.6	2.42	1.6	3.2	1.8	2.1	1.25	1.45	8.7	1.6	1.75
26	2.15	3.9	2.3	1.6	3.0	1.75	2.75	8.3	1.4	2.75	1.55	1.85
27	2.52	5.9	2.12	1.48	2.8	1.7	3.05	5.3	1.35	2.55	1.5	1.8
28	2.62	4.0	2.15	1.4	2.55	1.6	3.05	4.4	1.4	2.25	1.6	1.95
29	2.22	3.45	2.2	1.3	2.45	1.5	2.55	2.3	5.0	2.38	1.52	2.15
30	2.2	....	2.25	1.3	2.4	1.35	2.2	2.1	2.85	4.2	1.45	2.22
31	2.2	....	2.35	....	2.95	....	2.1	2.0	....	2.85	....	3.28
1909												
1	3.60	2.45	2.72	2.14	2.17	1.78	2.20	1.10	1.12	0.72	0.78	0.90
2	2.75	2.38	2.55	2.10	2.24	1.70	1.85	1.32	.98	.71	....	.94
3	2.52	2.22	2.50	2.07	2.10	1.85	1.60	1.60	.85	.70	....	.86
4	2.68	2.12	4.42	2.02	2.02	3.82	1.50	1.22	.82	.68	....	.84
5	2.95	2.15	3.22	2.02	1.92	5.55	1.45	1.12	.82	.67	....	.86

Daily gage height, in feet, of Rappahannock River near Fredericksburg, Va., for 1907–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
6	5.75	2.10	2.78	1.92	1.84	5.05	1.40	1.22	.82	.65	....	.86
7	3.55	2.05	3.00	1.90	1.84	3.40	1.48	1.22	.75	.70	....	.86
8	2.95	2.10	3.45	1.87	1.82	4.65	1.45	1.15	.72	.70	.81	.91
9	2.70	2.15	2.98	1.82	1.77	4.10	1.40	1.10	.74	.70	.82	.94
10	2.60	5.18	3.00	1.82	1.80	4.00	1.30	1.05	.79	.70	.85	.90
11	2.55	4.95	2.78	1.77	1.80	4.18	1.28	1.00	1.00	.68	.90	.90
12	2.38	3.40	2.52	1.77	1.90	3.45	1.28	.82	1.47	.68	.94	.90
13	2.25	2.90	2.51	1.80	1.80	2.80	1.28	.80	1.32	1.78	.92	1.12
14	2.32	2.72	2.88	6.47	1.72	6.65	1.20	.72	1.00	1.25	.94	3.54
15	2.45	2.65	2.68	6.10	1.67	5.65	1.28	.82	.90	1.04	.90	2.36
16	2.78	2.55	2.38	3.77	1.62	3.42	1.55	1.02	.83	.92	.90	1.78
17	2.72	2.55	2.28	3.24	1.57	2.95	1.38	1.55	1.12	.92	.94	1.30
18	2.62	2.42	2.25	2.97	1.52	3.52	1.30	1.95	1.59	.88	.92	1.35
19	2.55	2.82	2.25	2.82	1.46	2.85	1.25	1.55	1.28	.82	.92	1.26
20	2.42	3.72	2.20	2.68	1.42	2.55	1.20	1.22	1.14	.78	.90	1.12
21	2.52	3.20	2.15	2.64	1.80	2.22	1.12	1.22	1.04	.80	.84	1.02
22	3.25	2.92	2.15	2.80	4.94	2.12	1.05	1.75	.94	.79	.82	1.13
23	3.45	2.95	2.10	2.87	3.42	2.02	1.00	1.15	.87	.78	.88	1.16
24	4.78	4.35	2.05	3.17	2.84	2.00	.90	1.00	1.02	.82	.99	1.02
25	4.55	4.22	2.08	2.92	2.54	1.90	1.08	.95	1.43	.80	1.06	1.06
26	3.50	3.25	2.58	2.50	2.30	1.80	1.00	.92	1.04	.82	1.06	1.07
27	2.90	3.08	2.20	2.37	2.32	1.90	.90	.85	1.00	.82	.97	1.12
28	2.60	2.90	2.35	2.30	2.60	1.88	.90	.80	.96	.80	.93	1.16
29	2.48	....	3.15	2.24	2.37	2.78	.80	1.15	.86	.78	.91	1.04
30	2.78	....	2.58	2.17	2.07	2.72	.85	1.32	.74	.79	.92	1.07
31	2.62	....	2.28	....	1.87	....	1.02	1.42	....	.78	....	1.13
1910												
1	1.16	1.76	4.38	1.47	2.14	1.40	1.73	1.27	0.97	0.60	1.08	1.33
2	1.12	1.68	3.85	1.45	2.10	1.36	1.59	1.28	1.07	.62	1.08	1.17
3	1.18	1.78	3.15	1.60	2.02	1.36	1.46	1.63	1.47	.57	1.11	1.10
4	1.64	2.21	2.86	1.85	1.84	1.38	6.49	1.49	1.48	.50	1.18	.98
5	2.04	2.58	2.58	1.96	1.80	1.47	5.15	1.27	1.24	.48	1.16	.98
6	1.46	2.46	2.43	1.76	1.77	2.01	2.90	1.21	1.15	.48	1.08	1.02
7	1.93	1.80	2.33	1.69	1.64	1.93	2.25	1.14	1.06	.62	1.06	1.08
8	3.30	1.86	2.17	1.63	1.69	1.56	2.05	1.63	.97	1.31	1.06	1.18
9	3.69	1.96	2.07	1.52	1.74	1.48	2.05	1.35	.92	2.16	1.03	1.24
10	3.07	1.80	1.97	1.43	1.62	2.40	1.94	1.23	.83	1.94	1.02	1.17
11	2.48	1.74	2.01	1.89	1.60	3.72	2.15	1.18	.80	1.42	.99	1.16
12	2.52	1.53	2.13	1.89	1.61	5.76	2.69	1.27	.78	1.12	1.00	1.15
13	2.38	1.48	2.17	1.41	2.04	5.83	4.25	1.21	.76	1.01	1.00	1.12
14	2.27	1.62	2.01	1.50	2.04	4.48	3.59	1.14	1.04	.96	1.00	1.15
15	2.17	1.72	1.91	1.46	1.78	3.66	2.55	1.12	1.31	.92	1.00	1.18
16	2.30	1.93	1.81	1.41	1.64	3.18	2.13	1.21	1.06	.87	1.02	1.20
17	1.88	2.93	1.77	3.88	1.60	5.50	2.15	1.17	.87	.82	1.03	1.32
18	1.78	6.35	1.75	4.51	1.58	3.90	2.95	1.13	.82	.80	1.00	1.18
19	2.30	3.85	1.69	3.51	1.52	3.34	4.29	1.11	.77	.80	.99	1.22
20	2.32	3.09	1.66	2.95	1.48	3.15	3.08	1.09	.73	.77	.98	1.82
21	2.12	2.70	1.63	2.57	1.68	3.14	2.29	1.07	.72	1.98	.98	1.26
22	5.65	3.42	1.61	2.87	1.65	2.42	2.04	1.19	.72	1.74	1.00	1.18
23	3.65	3.20	1.57	2.17	2.20	2.34	1.84	1.21	.73	3.14	1.00	1.16
24	3.00	2.71	1.57	3.01	1.81	2.14	1.73	1.19	.71	2.16	1.00	1.34
25	2.48	2.42	1.56	2.67	1.80	2.04	1.61	1.17	.70	1.67	1.02	2.34
26	2.38	2.21	1.55	3.11	2.32	1.86	1.57	1.11	.67	1.47	1.02	2.11
27	2.19	2.07	1.49	2.70	1.82	1.80	1.53	1.17	.65	1.37	1.02	1.90
28	2.30	2.20	1.49	2.53	1.68	1.82	1.49	1.15	.64	1.28	1.06	1.86
29	2.50	....	1.45	2.33	1.58	2.22	1.39	1.11	.62	1.22	1.13	1.84
30	2.15	....	1.49	2.19	1.42	1.82	1.37	1.03	.62	1.17	1.27	2.74
31	1.92	....	1.49	....	1.40	....	1.32	.99	....	1.11	....	2.68

Daily gage height, in feet, of Rappahannock River near Fredericksburg, Va., for 1907-1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
1	2.8	2.7	1.65	1.8	1.9	1.17	1.11	0.49	4.7	0.97	1.41	1.85
2	4.5	2.6	1.6	1.7	1.85	1.48	1.05	.51	2.8	.96	1.39	1.75
3	4.0	2.5	1.6	1.65	1.8	1.28	.97	.46	2.5	.96	1.34	1.65
4	5.8	2.35	1.55	1.65	1.7	1.12	.85	.55	3.2	1.02	1.27	1.6
5	3.8	2.25	1.55	3.2	1.65	1.05	.88	2.15	2.45	1.03	1.27	1.55
6	2.9	2.1	1.55	4.0	1.6	1.30	.77	3.0	1.8	1.01	1.30	1.5
7	2.6	2.05	1.55	3.1	1.6	1.38	.87	2.3	1.65	.99	2.9	1.5
8	2.3	2.05	1.65	2.8	1.55	1.39	.89	1.6	1.35	1.01	2.45	1.49
9	2.25	2.45	1.6	2.8	1.6	1.44	.95	1.20	1.23	1.07	2.05	1.47
10	2.05	2.6	1.95	2.8	1.6	1.28	.97	.97	2.35	1.17	2.0	1.47
11	1.9	2.3	3.1	2.7	1.55	1.24	.81	.91	2.35	1.06	1.9	1.43
12	1.85	2.1	2.45	2.4	1.5	1.26	.84	.78	2.6	1.05	1.8	1.45
13	2.0	2.05	2.1	2.3	1.43	1.36	1.19	.80	2.05	1.10	1.85	1.43
14	2.45	1.95	2.3	2.2	1.36	1.6	.95	.80	1.55	1.13	1.9	1.41
15	2.3	1.9	2.35	2.2	1.34	1.40	.85	1.29	1.35	1.01	1.9	1.47
16	2.1	1.85	2.25	2.25	1.34	1.17	0.77	1.19	1.38	1.03	2.2	2.5
17	1.9	1.8	2.05	2.15	1.31	1.02	.74	.95	1.33	1.06	2.0	4.0
18	1.8	1.8	2.0	2.05	1.31	1.00	.69	.84	1.31	4.3	1.95	2.6
19	1.75	1.8	2.0	2.0	1.28	.97	.62	.73	1.23	3.6	2.25	2.2
20	1.75	1.8	2.15	2.2	1.25	1.06	.65	.69	1.15	2.45	2.05	2.0
21	1.75	2.35	2.05	2.2	1.19	1.02	.54	.66	1.39	1.95	1.9	2.0
22	1.75	2.15	1.9	2.05	1.18	1.00	.62	.60	1.21	1.95	1.75	2.0
23	2.3	1.9	1.8	2.2	1.15	.91	.57	.55	1.11	2.25	1.65	5.3
24	2.25	1.85	1.75	2.4	1.18	.87	.57	.52	1.09	2.25	1.7	4.5
25	2.1	1.8	1.65	2.2	1.15	1.20	.54	.49	1.04	1.9	2.0	3.7
26	2.05	1.75	1.6	2.0	1.11	2.1	.67	.48	1.65	1.7	1.8	3.1
27	2.4	1.7	1.6	1.95	1.10	1.7	.80	.53	1.43	1.65	1.7	3.4
28	2.35	1.7	1.9	1.85	1.07	1.65	1.10	1.25	1.06	1.55	1.7	3.1
29	2.25	....	1.85	1.85	1.04	1.75	.91	1.35	.97	1.47	2.0	2.6
30	2.9	....	1.85	1.85	1.00	1.36	.81	1.65	.99	1.42	2.5	2.4
31	3.2	....	1.95	....	1.00	....	.53	3.2	....	1.42	....	2.5
1912												
1	2.7	2.4	3.0	3.5	1.95	2.0	1.65	2.6	1.02	2.15	1.44	1.45
2	2.35	2.2	2.8	3.2	1.9	1.9	1.65	2.1	.97	2.05	1.44	1.44
3	2.2	2.25	2.5	3.7	1.85	1.85	1.7	1.55	1.24	1.95	1.43	1.48
4	2.25	2.2	2.35	3.1	1.75	1.75	1.55	1.40	1.42	1.85	1.39	1.5
5	2.2	1.85	2.35	2.7	1.75	1.75	1.38	1.28	1.20	1.75	1.40	1.49
6	1.75	1.75	2.2	2.6	1.75	1.7	1.32	1.18	1.10	1.75	1.39	1.75
7	2.2	1.8	2.2	2.6	1.85	2.25	1.28	1.10	1.16	1.65	1.55	1.9
8	2.25	1.8	2.8	2.5	3.8	2.05	1.25	1.07	3.0	1.65	5.4	1.85
9	2.25	1.8	3.0	2.35	3.9	1.85	1.23	1.05	2.3	1.55	3.4	1.6
10	2.1	1.7	2.9	2.25	2.6	1.65	1.18	2.2	1.7	1.5	2.8	1.55
11	2.0	1.65	2.6	2.2	2.25	1.55	1.11	2.6	1.26	1.48	2.3	1.48
12	2.05	1.65	2.8	2.15	3.5	1.5	1.30	2.2	1.12	1.47	2.15	1.5
13	2.05	1.65	6.9	2.1	9.0	1.45	1.65	1.75	1.01	1.44	2.05	1.48
14	2.2	1.6	4.2	2.15	5.8	1.45	1.55	1.6	.95	1.44	2.0	1.40
15	2.2	1.6	6.1	2.2	3.6	1.49	4.5	1.7	.94	1.55	1.95	1.40
16	2.2	1.65	7.7	2.15	5.3	1.43	3.2	1.5	.98	1.55	1.85	1.48
17	2.2	1.7	5.5	2.35	6.4	1.65	1.7	1.38	.90	1.49	1.75	1.48
18	2.05	1.7	4.0	2.35	4.2	2.25	1.30	1.30	.90	1.41	1.7	1.45
19	2.25	1.95	3.8	2.8	3.6	1.85	3.2	1.25	1.26	1.33	1.65	1.65
20	2.8	2.1	3.0	2.2	3.2	1.75	2.15	1.28	1.38	1.41	1.65	2.0
21	2.5	2.25	2.9	2.15	2.9	1.7	1.85	1.30	1.49	1.40	1.65	1.75
22	2.4	5.5	2.8	2.1	2.7	1.6	1.7	1.25	1.5	1.41	1.65	1.55
23	2.4	3.6	2.6	2.15	2.6	1.65	1.55	1.19	1.7	1.43	1.6	1.5
24	2.3	2.7	2.8	2.1	2.4	1.5	1.34	1.10	6.2	2.45	1.55	1.46
25	2.4	2.6	3.4	1.95	2.4	1.55	1.55	1.06	9.8	2.0	1.55	1.42

Daily gage height, in feet, of Rappahannock River near Fredericksburg, Va., for 1907–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
26	2.25	2.8	3.0	1.9	2.25	2.0	1.9	1.00	5.7	1.7	1.55	1.43
27	2.0	6.8	2.7	1.9	2.15	2.25	1.75	1.08	3.4	1.6	1.5	1.75
28	2.05	4.1	2.6	1.9	2.1	2.8	1.40	1.04	3.1	1.49	1.55	2.8
29	2.1	3.2	6.9	1.95	2.05	2.4	1.30	1.09	2.8	1.44	1.47	2.35
30	2.25	....	5.9	1.9	2.05	1.95	1.43	1.10	2.45	1.45	1.47	2.35
31	2.4	....	4.3	....	2.15	....	1.48	1.07	....	1.43	....	5.5
1913												
1	3.7	2.25	1.85	2.6	2.15	3.2	1.75	1.08	0.61	0.68	....	1.5
2	2.9	2.15	1.75	2.4	2.1	2.8	1.6	1.20	.59	1.8	....	1.47
3	3.1	2.05	1.65	2.3	2.05	2.5	3.4	1.02	.64	1.13	....	1.44
4	4.0	3.0	1.6	2.25	2.0	4.5	2.1	.98	.61	.99	1.16	1.44
5	3.2	2.8	1.6	2.35	2.7	4.1	1.65	.99	.58	.93	1.15	1.40
6	2.7	2.5	1.6	2.2	2.1	3.0	1.6	.93	.58	.84	1.11	1.36
7	2.5	2.35	1.55	2.05	1.95	2.8	1.9	.92	.64	.78	1.04	1.39
8	2.5	2.15	1.48	2.0	1.9	2.7	1.65	.84	.64	.73	1.06	1.34
9	2.45	2.1	1.5	2.0	1.85	2.6	1.5	.88	.51	.70	1.16	1.42
10	2.3	2.05	1.55	1.95	1.9	2.4	1.55	.94	.57	.76	3.9	1.34
11	2.2	2.0	1.85	1.9	1.75	2.15	2.3	.91	.51	.81	2.5	1.31
12	2.15	2.0	2.15	7.3	1.65	2.05	2.25	.98	.48	1.01	2.05	1.26
13	2.15	1.95	2.15	9.8	1.75	2.0	1.8	1.12	.70	1.01	1.8	1.22
14	2.0	1.8	6.2	6.5	1.7	1.9	1.7	1.19	.58	.92	1.7	1.24
15	1.95	1.75	7.4	4.6	1.75	1.8	1.5	1.19	.60	.87	1.6	1.24
16	1.9	1.75	5.1	4.5	1.8	1.75	1.41	1.08	.62	.79	1.65	1.24
17	1.9	1.8	4.1	4.9	2.0	1.7	1.36	1.02	.58	.74	1.85	1.26
18	1.9	1.8	3.3	4.0	1.9	1.65	1.39	.94	.64	.76	1.9	1.24
19	1.9	1.75	3.0	3.5	1.85	1.6	1.46	.88	.66	.83	1.7	1.14
20	1.85	1.7	2.9	3.2	1.75	1.55	1.42	.90	.64	.88	1.55	1.20
21	1.8	1.75	2.8	2.9	1.75	1.55	1.34	1.19	.84	1.34	1.55	1.20
22	1.75	1.75	2.8	2.8	1.65	1.55	1.55	1.13	1.65	1.6	1.5	1.18
23	1.75	1.75	2.7	2.7	2.15	1.5	1.30	.97	1.7	1.27	1.44	1.18
24	1.9	1.7	2.4	2.6	9.3	1.7	1.21	.98	1.13	1.18	1.38	1.9
25	2.3	1.65	2.35	2.5	5.0	2.15	1.17	.88	.92	2.3	1.31	2.1
26	2.6	1.6	2.3	2.45	3.2	3.0	1.22	.84	.82	2.7	1.25	4.4
27	2.25	1.65	3.2	2.4	2.7	2.8	1.18	.80	.73	2.2	1.34	3.5
28	3.7	1.75	4.1	2.4	4.2	2.9	1.13	.73	.71	1.8	1.35	2.8
29	2.9	....	3.5	2.4	3.8	2.15	1.08	.70	.70	1.55	1.5	2.2
30	2.5	....	3.0	2.25	3.25	1.9	1.09	.70	.64	1.42	1.6	2.1
31	2.35	....	2.8	....	3.6	....	1.11	.66	....	1.20	....	2.0
1914												
1	1.9	4.8	2.5	2.25	2.6	1.18	1.09	0.66	0.98	0.47	0.81	1.06
2	1.75	3.4	2.15	2.3	2.4	1.15	1.09	.63	.81	.48	.79	1.09
3	2.4	2.9	2.2	2.2	2.3	1.12	1.10	.59	.64	.48	.78	1.19
4	8.6	2.7	2.25	2.1	2.2	1.09	1.02	.52	.95	.46	.78	1.18
5	6.1	2.5	2.35	2.0	2.25	1.34	2.05	.55	1.20	.44	.77	1.17
6	4.0	2.5	2.4	1.95	2.65	1.39	1.75	.56	.84	.40	.77	1.8
7	3.2	3.3	2.5	1.95	2.3	1.18	1.55	.54	.60	.45	.76	2.8
8	2.9	3.4	2.8	1.9	2.1	1.13	1.5	.48	.51	.50	.73	3.1
9	2.7	2.7	3.3	2.25	2.2	1.08	1.30	.47	.54	.52	.79	2.6
10	2.5	2.45	3.2	2.1	2.0	1.06	1.09	.46	.47	.52	.83	2.2
11	2.35	2.4	3.1	1.95	1.95	1.04	1.18	1.22	.46	.52	.85	2.3
12	2.15	2.35	2.8	1.85	1.85	1.04	1.04	.59	.53	.52	.78	2.2
13	2.0	2.3	2.5	1.8	1.8	.97	.86	.49	.52	.49	.77	2.2
14	1.7	2.35	2.9	1.75	1.95	.91	2.3	.43	.46	.50	.76	2.8
15	1.8	2.35	3.4	1.95	2.0	1.10	2.05	.52	.70	.51	1.09	2.5
16	1.85	2.35	3.3	4.0	1.8	1.26	1.42	.48	.64	1.75	4.6	2.0
17	1.9	2.3	3.1	3.1	1.65	1.10	1.19	.40	.61	3.3	2.7	1.6
18	1.85	2.25	3.4	2.7	1.65	1.09	1.32	.34	.54	1.95	1.95	1.65
19	1.8	2.15	3.6	2.4	1.6	.99	1.12	.37	.51	1.5	1.7	1.65
20	1.75	2.25	3.0	2.4	1.6	.88	1.03	.37	.48	1.28	1.5	1.9

Daily gage height, in feet, of Rappahannock River near Fredericksburg, Va., for 1907–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1914												
21	1.7	2.8	2.9	3.2	1.5	.91	.88	.81	.48	1.14	1.40	2.25
22	1.75	2.6	2.8	2.9	1.49	.98	.82	.96	.42	1.04	1.36	3.2
23	1.65	2.4	2.9	2.85	1.47	1.04	.70	1.29	.42	.98	1.29	2.45
24	1.7	2.3	2.8	2.2	1.44	1.29	.64	.84	.47	.94	1.27	2.1
25	3.4	2.15	2.6	2.15	1.38	1.12	.59	.85	.54	.95	1.12	1.95
26	3.1	2.15	2.45	6.0	1.31	2.5	1.27	1.65	.81	.98	1.11	1.85
27	2.45	2.3	2.3	5.0	1.31	1.5	1.14	2.05	.84	.91	1.11	1.65
28	2.2	2.4	2.25	3.7	1.28	1.8	.92	1.40	.66	.88	1.08	1.65
29	2.15	....	2.35	3.1	1.25	1.8	.82	1.18	.54	.83	1.08	1.9
30	2.05	....	2.25	2.9	1.24	1.40	.70	1.23	.54	.79	1.08	2.45
31	2.05	....	2.3	....	1.24	....	.73	1.20	....	.79	....	3.0

NOTE.—Gage out Feb. 14-19, 1908; Nov. 2-7, 1909; and Nov. 1-3, 1913. Ice usually forms near the gage, but the effect on discharge relation is probably negligible. All gage readings are probably to water surface.

Daily discharge, in second-feet, of Rappahannock River near Fredericksburg, Va., for 1907–1914.

Day	Sept.	Oct.	Nov.	Dec.	Day	Sept.	Oct.	Nov.	Dec.	Day	Sept.	Oct.	Nov.	Dec.
1907					1907					1907				
1	......	1,350	510	1,520	11	......	729	1,780	9,030	21	486	510	1,690	1,960
2	......	1,140	510	1,520	12	......	729	1,310	5,100	22	486	584	1,660	1,810
3	......	985	3,540	1,380	13	......	697	1,050	3,190	23	1,690	510	1,740	5,050
4	......	961	2,120	1,240	14	......	645	961	3,480	24	24,900	510	9,760	10,700
5	......	925	1,080	1,240	15	......	645	865	7,130	25	3,580	510	9,210	4,640
6	......	925	925	1,050	16	......	598	808	4,250	26	2,380	486	4,040	3,880
7	......	778	1,140	1,050	17	......	598	808	3,290	27	1,780	470	2,910	3,000
8	......	808	1,440	1,050	18	......	598	842	2,850	28	1,520	550	2,320	3,000
9	......	865	1,010	1,050	19	486	598	1,890	2,640	29	2,040	842	2,000	2,430
10	......	773	1,080	2,960	20	470	550	1,930	2,210	30	1,930	666	1,810	2,640
										31	......	550	......	3,350

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
1	3,100	1,520	3,880	2,460	598	3,690	1,520	1,590	1,110	1,690	2,210	750
2	2,090	1,660	3,580	2,210	510	2,720	1,810	1,180	1,010	1,590	1,740	808
3	1,930	1,520	3,100	2,120	925	1,890	2,120	1,010	865	1,380	1,520	645
4	1,840	1,520	2,820	1,740	808	2,640	2,040	865	808	1,240	1,660	750
5	1,810	2,290	2,460	1,630	808	4,980	2,040	750	750	1,110	1,520	750
6	1,740	3,000	5,630	1,660	925	2,380	1,890	645	16,300	889	1,240	687
7	2,290	1,810	5,910	1,520	2,210	1,890	1,740	550	3,880	985	1,240	1,140
8	14,100	2,910	4,210	1,520	3,750	1,740	1,520	550	1,810	865	1,110	961
9	4,830	2,460	3,190	1,440	3,690	1,590	889	697	1,380	773	985	750
10	2,380	2,290	3,290	1,660	1,590	1,310	697	666	1,240	925	1,050	808
11	4,760	2,290	3,580	1,690	1,520	1,810	598	750	985	1,080	985	865
12	23,100	2,780	2,720	1,380	1,440	1,740	550	598	985	2,290	961	3,100
13	24,600	3,750	2,640	1,540	1,310	1,440	510	550	773	1,440	1,180	2,500
14	7,440	12,000	2,320	1,240	1,210	1,310	432	550	666	1,180	1,110	1,380
15	4,870	20,000	1,960	1,310	1,080	1,180	395	470	697	1,110	1,050	1,080

Daily discharge, in second-feet, of Rappahannock River near Fredericksburg, Va., for 1907-1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
16	4,040	13,000	2,090	1,240	1,050	4,760	362	455	550	925	1,380	1,080
17	3,480	7,000	1,960	1,050	985	3,900	329	395	598	865	1,520	1,050
18	3,000	4,000	2,120	1,180	925	2,550	270	2,640	550	865	1,240	865
19	2,640	8,000	2,120	1,310	925	2,550	395	1,810	550	808	1,240	985
20	2,460	4,980	1,960	1,380	4,640	2,210	395	865	510	865	1,180	925
21	1,380	4,540	1,660	1,240	7,220	1,810	329	598	550	808	985	750
22	2,210	8,100	1,660	1,110	22,100	1,440	270	510	697	750	1,050	808
23	2,120	3,000	1,890	1,110	7,540	1,310	865	550	750	666	985	808
24	1,960	2,670	2,040	865	8,900	1,590	1,660	598	750	645	808	645
25	1,960	2,290	2,000	865	3,380	1,110	1,520	510	697	4,420	865	1,050
26	1,590	4,870	1,810	865	3,000	1,050	2,550	22,100	645	2,550	808	1,180
27	2,160	11,300	1,540	729	2,640	985	3,100	9,030	598	2,210	750	1,110
28	2,320	5,100	1,590	645	2,210	865	3,100	6,190	645	1,740	865	1,310
29	1,690	3,900	1,660	550	2,040	750	2,210	1,810	8,010	1,930	773	1,590
30	1,660	....	1,740	550	1,960	598	1,660	1,520	2,720	5,630	698	1,690
31	1,660	....	1,890	....	2,910	....	1,520	1,380	....	2,720	....	3,540
1909												
1	4,210	2,040	2,500	1,570	1,620	1,080	1,660	395	410	187	212	270
2	2,550	1,930	2,210	1,520	1,720	985	1,180	569	317	183	214	294
3	2,160	1,690	2,120	1,470	1,520	1,180	865	865	245	179	216	250
4	2,430	1,540	6,250	1,400	1,400	4,690	750	486	230	172	218	240
5	2,910	1,590	8,420	1,400	1,270	9,940	698	410	230	168	219	250
6	10,700	1,520	2,600	1,270	1,160	8,180	645	486	230	162	221	250
7	4,100	1,440	3,000	1,240	1,160	3,790	729	486	200	179	223	250
8	2,910	1,520	3,900	1,200	1,140	6,920	698	432	187	179	225	276
9	2,460	1,590	2,960	1,140	1,070	5,360	645	395	195	179	230	294
10	2,290	8,610	3,000	1,140	1,110	5,100	550	362	216	179	245	270
11	2,210	7,850	2,600	1,070	1,110	5,580	534	329	329	172	270	270
12	1,930	3,790	2,160	1,070	1,240	3,900	534	230	718	172	294	270
13	1,740	2,820	2,140	1,110	1,110	2,640	534	220	569	1,080	282	410
14	1,840	2,500	2,780	18,600	1,010	14,300	470	187	329	510	294	4,080
15	2,040	2,380	2,430	12,000	949	10,300	534	230	270	355	270	1,900
16	2,600	2,210	1,930	4,580	889	3,830	808	342	285	282	270	1,080
17	2,500	2,210	1,780	3,460	830	2,910	626	808	410	282	294	550
18	2,320	2,000	1,740	2,940	773	4,040	550	1,310	854	260	282	598
19	2,210	1,840	1,740	2,670	710	2,720	510	808	584	230	282	518
20	2,000	4,470	1,660	2,480	670	2,210	470	486	425	212	270	410
21	2,160	3,380	1,590	2,360	1,110	1,690	410	486	355	220	240	342
22	3,480	2,850	1,590	2,640	7,820	1,540	362	1,050	294	216	230	418
23	3,900	2,910	1,520	2,760	3,830	1,400	329	432	255	212	260	440
24	7,820	6,050	1,440	3,330	2,710	1,380	270	329	342	230	323	342
25	6,620	5,690	1,490	2,850	2,190	1,240	382	300	676	220	369	369
26	4,000	3,480	2,260	2,120	1,810	1,110	329	282	355	230	369	375
27	2,820	3,150	1,660	1,920	1,840	1,240	270	245	329	230	311	410
28	2,290	2,820	1,890	1,810	2,290	1,210	270	220	305	220	288	440
29	2,090	....	3,290	1,720	1,920	2,600	220	432	250	212	276	355
30	2,600	....	2,260	1,620	1,470	2,500	245	569	195	216	282	375
31	2,320	....	1,780	....	1,200	....	342	666	....	212	....	418
1910												
1	440	1,060	6,130	718	1,570	645	1,020	526	311	144	382	578
2	410	961	4,760	698	1,520	607	854	494	375	151	382	448
3	455	1,080	3,290	865	1,400	607	708	901	718	185	402	395
4	913	1,680	2,740	1,180	1,160	626	13,700	740	676	115	455	317
5	1,430	2,260	2,260	1,320	1,110	718	8,510	526	502	110	440	317
6	708	2,060	2,010	1,060	1,070	1,390	2,820	478	432	110	382	342
7	1,280	1,110	1,860	973	913	1,280	1,740	425	369	151	369	349
8	3,580	1,190	1,620	901	973	819	1,440	901	311	560	369	455
9	4,400	1,320	1,470	773	1,040	729	1,440	598	282	1,600	349	502
10	3,130	1,110	1,330	676	889	1,960	1,290	494	235	1,290	342	448

Daily discharge, in second-feet, of Rappahannock River near Fredericksburg, Va., for 1907–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
11	2,090	1,040	1,390	634	865	4,470	1,590	418	220	666	323	440
12	2,160	784	1,560	634	877	10,700	2,440	526	212	410	329	432
13	1,980	729	1,620	656	1,430	11,000	5,770	478	204	336	329	410
14	1,760	889	1,390	750	1,430	6,420	4,190	425	355	305	329	432
15	1,620	1,010	1,250	708	1,080	4,340	2,210	410	560	282	329	455
16	1,810	1,280	1,120	656	913	3,350	1,560	478	369	255	342	470
17	1,210	2,870	1,070	3,750	865	9,760	1,590	448	255	230	349	569
18	1,080	13,100	1,050	6,510	842	4,870	2,910	418	230	220	329	455
19	1,810	4,760	973	4,020	773	3,670	5,880	402	208	220	323	486
20	1,840	3,170	937	2,910	729	3,290	3,150	388	191	208	317	569
21	1,540	2,460	901	2,240	961	3,270	1,800	375	187	1,350	317	518
22	10,300	3,830	877	1,920	925	2,000	1,430	462	187	1,040	329	455
23	4,320	3,380	830	1,620	1,660	1,870	1,160	478	191	3,270	329	440
24	3,000	2,480	830	3,020	1,120	1,570	1,020	462	183	1,600	329	588
25	2,090	2,000	819	2,410	1,110	1,430	877	448	179	949	342	1,870
26	1,980	1,680	808	3,210	1,840	1,190	830	402	168	718	342	1,530
27	1,650	1,470	740	2,460	1,140	1,110	784	448	162	616	342	1,240
28	1,810	1,660	740	2,170	961	1,140	740	432	158	534	369	1,190
29	2,120	....	698	1,860	842	1,690	634	402	151	486	418	1,160
30	1,590	....	740	1,650	666	1,140	616	349	151	448	526	2,530
31	1,270	....	740	....	645	....	569	323	....	402	....	2,480
1911												
1	2,570	2,400	918	1,100	1,220	448	402	118	7,070	311	656	1,160
2	6,480	2,240	860	975	1,160	729	362	118	2,570	305	636	1,040
3	5,100	2,080	860	918	1,100	534	311	106	2,080	305	588	918
4	10,900	1,840	805	918	975	410	245	130	3,290	342	526	860
5	4,610	1,700	805	3,290	918	362	235	1,560	2,000	349	526	805
6	2,740	1,480	805	5,100	860	550	208	2,920	1,100	336	550	750
7	2,240	1,420	805	3,100	860	626	255	1,770	918	323	2,740	750
8	1,770	1,420	918	2,570	835	636	265	860	598	336	2,000	740
9	1,700	2,000	860	2,570	860	687	300	470	494	375	1,420	718
10	1,420	2,240	1,280	2,570	860	534	311	311	1,840	448	1,350	718
11	1,220	1,770	3,100	2,400	805	502	225	276	1,840	369	1,220	676
12	1,160	1,480	2,000	1,920	750	518	240	212	2,240	362	1,100	698
13	1,350	1,420	1,480	1,770	676	607	462	220	1,420	395	1,160	676
14	2,000	1,280	1,770	1,620	607	860	300	220	805	418	1,220	656
15	1,770	1,220	1,840	1,620	588	645	245	542	598	336	1,220	718
16	1,480	1,160	1,700	1,700	588	448	208	462	578	349	1,620	2,080
17	1,220	1,100	1,420	1,560	560	342	195	300	578	369	1,350	5,100
18	1,100	1,100	1,350	1,420	560	329	176	240	560	5,910	1,280	2,240
19	1,040	1,100	1,850	1,350	534	311	151	191	494	4,140	1,700	1,620
20	1,040	1,100	1,560	1,620	510	369	162	176	432	2,000	1,420	1,350
21	1,040	1,840	1,420	1,620	462	342	127	165	636	1,280	1,220	1,850
22	1,040	1,560	1,220	1,420	455	329	151	144	478	1,280	1,040	1,350
23	1,770	1,220	1,100	1,620	432	276	135	130	402	1,700	918	9,080
24	1,700	1,160	1,040	1,920	455	255	135	121	388	1,700	975	6,480
25	1,480	1,100	918	1,620	432	470	127	118	355	1,220	1,350	4,370
26	1,420	1,040	860	1,350	402	1,480	168	110	918	975	1,100	3,100
27	1,920	975	860	1,280	395	975	220	124	676	918	975	3,700
28	1,840	975	1,220	1,160	375	918	395	510	369	805	975	3,100
29	1,700	....	1,160	1,160	355	1,040	276	598	311	718	1,350	2,240
30	2,740	....	1,160	1,160	329	607	225	918	323	666	2,080	1,920
31	3,290	....	1,280	....	329	....	124	3,290	....	666	....	2,080
1912												
1	2,400	1,920	2,920	3,920	1,280	1,350	918	2,240	342	1,560	687	698
2	1,840	1,620	2,570	3,290	1,220	1,220	918	1,480	311	1,420	687	687
3	1,620	1,700	2,080	4,370	1,160	1,160	975	805	502	1,280	676	729
4	1,700	1,620	1,840	3,100	1,040	1,040	805	645	666	1,160	636	750
5	1,620	1,160	1,840	2,400	1,040	1,040	626	534	470	1,040	645	740

Daily discharge, in second-feet, of Rappahannock River near Fredericksburg, Va., for 1907–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
6	1,040	1,040	1,620	2,240	1,040	975	569	455	395	1,040	636	1,040
7	1,620	1,100	1,620	2,240	1,160	1,700	534	395	440	918	805	1,220
8	1,700	1,100	2,570	2,080	4,610	1,420	510	375	2,920	918	9,390	1,160
9	1,700	1,100	2,920	1,840	4,850	1,160	494	362	1,770	805	3,700	860
10	1,480	975	2,740	1,700	2,240	918	456	1,620	975	750	2,570	805
11	1,350	918	2,240	1,620	1,700	805	402	2,240	518	729	1,770	729
12	1,420	918	2,570	1,560	3,920	750	550	1,620	410	718	1,560	750
13	1,420	918	15,400	1,480	25,700	698	918	1,040	336	687	1,420	729
14	1,620	860	5,630	1,560	10,900	698	805	860	300	687	1,350	645
15	1,620	860	12,000	1,620	4,140	740	6,480	975	294	805	1,280	645
16	1,620	918	19,100	1,560	9,030	676	3,290	750	288	805	1,160	676
17	1,620	975	9,760	1,840	13,300	918	975	626	270	740	1,040	676
18	1,420	975	5,100	1,840	5,630	1,700	550	530	270	656	975	698
19	1,700	1,280	3,490	1,770	4,140	1,160	3,290	510	518	578	918	918
20	2,570	1,480	2,920	1,620	3,290	1,040	1,560	534	626	656	918	1,350
21	2,080	1,700	2,740	1,560	2,740	975	1,160	550	740	645	918	1,040
22	1,920	9,760	2,570	1,480	2,400	860	975	510	750	656	918	805
23	1,920	4,140	2,240	1,560	2,240	918	805	462	975	676	860	750
24	1,770	2,400	2,570	1,480	1,920	750	588	395	12,400	2,000	805	708
25	1,920	2,240	3,700	1,280	1,920	805	805	362	29,800	1,350	805	666
26	1,700	2,570	2,920	1,220	1,700	1,350	1,220	329	10,500	975	805	676
27	1,350	15,000	2,400	1,220	1,560	1,700	1,040	382	3,700	860	750	1,040
28	1,420	5,360	2,240	1,220	1,480	2,570	645	355	3,100	740	805	2,570
29	1,480	3,290	15,400	1,280	1,420	1,920	530	388	2,570	687	718	1,840
30	1,700	....	11,300	1,220	1,420	1,280	676	395	2,000	698	718	1,840
31	1,920	....	5,910	....	1,560	....	729	375	....	676	....	9,760
1913												
1	4,370	1,700	1,160	2,240	1,560	3,290	1,040	382	148	172	462	750
2	2,740	1,560	1,040	1,920	1,480	2,570	860	470	141	1,100	455	718
3	3,100	1,420	918	1,770	1,420	2,080	3,700	342	158	418	448	687
4	5,100	2,920	860	1,700	1,350	6,480	1,480	317	148	323	440	687
5	3,290	2,570	860	1,840	2,400	5,360	918	323	138	288	432	645
6	2,400	2,080	860	1,620	1,480	2,920	860	288	138	240	402	607
7	2,080	1,840	805	1,420	1,280	2,570	1,220	282	158	212	355	636
8	2,080	1,560	729	1,350	1,220	2,400	918	240	158	191	369	588
9	2,000	1,480	750	1,350	1,160	2,240	750	260	118	179	440	666
10	1,770	1,420	805	1,280	1,220	1,920	805	294	135	204	4,850	588
11	1,620	1,350	1,160	1,220	1,040	1,560	1,770	276	118	225	2,080	560
12	1,560	1,350	1,560	17,200	918	1,420	1,700	317	110	396	1,420	518
13	1,560	1,280	1,560	29,800	1,040	1,350	1,100	410	179	336	1,100	486
14	1,350	1,100	12,400	13,700	975	1,220	975	462	138	282	975	502
15	1,280	1,040	17,700	6,770	1,040	1,100	750	462	144	255	860	502
16	1,220	1,040	8,340	6,480	1,100	1,040	656	382	151	216	918	502
17	1,220	1,100	5,360	7,690	1,350	975	607	342	138	195	1,160	518
18	1,220	1,100	3,490	5,100	1,220	918	636	294	158	204	1,220	502
19	1,220	1,040	2,920	3,920	1,160	860	708	260	165	235	975	425
20	1,160	975	2,740	3,290	1,040	805	666	270	158	260	805	470
21	1,100	1,040	2,570	2,740	1,040	805	588	462	240	588	805	470
22	1,040	1,040	2,570	2,570	918	805	805	418	918	860	750	455
23	1,040	1,040	2,400	2,400	1,560	750	550	311	975	526	687	455
24	1,220	975	1,920	2,240	27,200	975	478	317	418	455	626	1,220
25	1,770	918	1,840	2,080	8,010	1,560	448	260	282	1,770	560	1,480
26	2,240	860	1,770	2,000	3,290	2,920	486	240	230	2,400	510	6,190
27	1,700	918	3,290	1,920	2,400	2,570	455	220	191	1,620	588	3,920
28	4,370	1,040	5,360	1,920	5,630	2,740	418	191	183	1,100	598	2,570
29	2,740	....	3,920	1,920	4,610	1,560	382	179	179	805	750	1,620
30	2,080	....	2,920	1,700	3,390	1,220	388	179	158	666	860	1,480
31	1,840	....	2,570	....	4,140	....	402	165	....	470	....	1,350

Daily discharge, in second-feet, of Rappahannock River near Fredericksburg, Va., for 1907–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1914												
1	1,220	7,380	2,080	1,700	2,240	455	388	165	288	108	225	369
2	1,040	3,700	1,560	1,770	1,920	432	388	154	225	110	216	388
3	1,920	2,740	1,620	1,620	1,770	410	395	141	158	110	212	462
4	23,600	2,400	1,700	1,480	1,620	388	342	121	800	106	212	455
5	12,000	2,080	1,840	1,850	1,700	588	1,420	130	470	101	208	448
6	5,100	2,080	1,920	1,280	2,320	636	1,040	132	240	92	208	1,100
7	3,290	3,490	2,080	1,280	1,770	455	805	127	144	104	204	2,570
8	2,740	3,700	2,570	1,220	1,480	418	750	110	118	115	191	3,100
9	2,400	2,400	3,490	1,700	1,620	382	550	108	127	121	216	2,240
10	2,080	2,000	3,290	1,480	1,350	369	388	106	108	121	235	1,620
11	1,840	1,920	3,100	1,280	1,280	355	455	486	106	121	245	1,770
12	1,560	1,840	2,570	1,160	1,160	355	355	141	124	121	212	1,620
13	1,350	1,770	2,080	1,100	1,100	311	250	113	121	118	208	1,620
14	975	1,840	2,740	1,040	1,280	276	1,770	99	106	115	204	2,570
15	1,100	1,840	3,700	1,280	1,350	395	1,420	121	179	118	388	2,080
16	1,160	1,840	3,490	5,100	1,100	518	666	110	158	1,040	6,770	1,850
17	1,220	1,770	3,100	3,100	918	395	462	92	148	3,490	2,400	860
18	1,160	1,700	3,700	2,400	918	388	569	80	127	1,280	1,280	918
19	1,100	1,560	4,140	1,920	860	323	410	86	118	750	975	918
20	1,040	1,700	2,920	1,920	860	260	349	86	110	534	750	1,220
21	975	2,570	2,740	3,290	750	276	260	74	110	425	645	1,700
22	1,040	2,240	2,570	2,740	740	317	230	305	97	355	607	3,290
23	918	1,920	2,740	1,840	718	355	179	542	97	317	542	2,000
24	975	1,770	2,570	1,620	687	542	158	240	108	294	526	1,480
25	3,700	1,560	2,240	1,560	626	410	141	245	127	300	410	1,280
26	3,100	1,560	2,000	11,600	560	2,080	526	918	225	288	402	1,160
27	2,000	1,770	1,770	8,010	560	750	425	1,420	240	276	402	918
28	1,620	1,920	1,700	4,870	534	1,100	282	645	165	260	382	918
29	1,560	....	1,840	3,100	510	1,100	230	455	127	235	382	1,220
30	1,420	....	1,700	2,740	502	645	179	494	127	216	382	2,000
31	1,420	....	1,770	....	502	....	191	470	....	216	....	2,920

NOTE.—Discharge determined from a rating curve well defined above 500 second-feet and fairly well defined below. No corrections have been made for probable effect of ice. Discharge Feb. 14-19, 1908, estimated by comparison with records of other stations. Discharge interpolated Nov. 2-7, 1909, and Nov. 1-3, 1913.

Monthly discharge of Rappahannock River near Fredericksburg, Va., for 1907–1914.

[Drainage area, 1,590 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1907						
September 19-30	24,900	470	3,480	2.19	0.98	A.
October	1,350	470	711	.447	.52	A.
November	9,760	510	2,090	1.31	1.46	A.
December	10,700	1,050	3,200	2.01	2.32	A.

Monthly discharge of Rappahannock River near Fredericksburg, Va., for 1907–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1908						
January	24,600	1,880	4,430	2.79	3.22	A.
February	20,000	1,520	4,810	3.08	3.27	C.
March	5,910	1,540	2,600	1.64	1.89	A.
April	2,460	550	1,330	.836	.93	A.
May	22,100	510	2,900	1.82	2.10	A.
June	4,980	598	1,990	1.25	1.40	A.
July	3,100	270	1,270	.799	.92	A.
August	22,100	395	2,010	1.26	1.45	A.
September	16,300	510	1,720	1.08	1.20	A.
October	5,630	645	1,510	.950	1.10	A.
November	2,210	698	1,160	.730	.81	A.
December	3,540	645	1,170	.736	.85	A.
The year	24,600	270	2,230	1.40	19.12	
1909						
January	10,700	1,740	3,150	1.98	2.28	A.
February	8,610	1,440	3,070	1.93	2.01	A.
March	6,250	1,440	2,380	1.50	1.73	A.
April	13,600	1,070	2,710	1.70	1.90	A.
May	7,820	670	1,630	1.03	1.19	A.
June	14,300	985	3,850	2.42	2.70	A.
July	1,660	220	562	.353	.41	A.
August	1,310	187	479	.301	.35	B.
September	854	187	350	.220	.25	B.
October	1,080	162	250	.157	.18	B.
November	369	212	266	.167	.19	B.
December	4,080	240	549	.345	.40	A.
The year	14,300	162	1,590	1.00	13.59	
1910						
January	10,300	410	2,120	1.33	1.53	A.
February	13,100	729	2,230	1.40	1.46	A.
March	6,130	698	1,570	.987	1.14	A.
April	6,510	634	1,760	1.11	1.24	A.
May	1,840	645	1,070	.673	.78	A.
June	11,000	607	2,920	1.84	2.05	A.
July	13,700	569	2,430	1.53	1.76	A.
August	901	323	486	.306	.35	B.
September	718	151	291	.183	.20	B.
October	3,270	110	610	.384	.44	A.
November	526	317	360	.226	.25	B.
December	2,530	317	740	.465	.54	A.
The year	13,700	110	1,380	.868	11.76	
1911						
January	10,900	1,040	2,350	1.48	1.71	A.
February	2,400	975	1,480	.931	.97	A.
March	3,100	805	1,250	.786	.91	A.
April	5,100	918	1,810	1.14	1.27	A.
May	1,220	329	652	.410	.47	A.
June	1,480	255	571	.359	.40	A.
July	462	124	237	.149	.17	B.
August	3,290	106	562	.353	.41	A.
September	7,070	311	1,210	.761	.85	A.
October	5,910	305	968	.609	.70	A.
November	2,740	526	1,210	.761	.85	A.
December	9,030	656	2,080	1.28	1.48	A.
The year	10,900	106	1,190	.748	10.19	

Monthly discharge of Rappahannock River near Fredericksburg, Va., for 1907–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1912						
January	2,570	1,040	1,690	1.06	1.22	B.
February	15,000	860	2,410	1.52	1.64	A.
March	19,100	1,620	5,000	3.14	3.62	A.
April	4,370	1,220	1,910	1.20	1.34	A.
May	25,700	1,040	3,930	2.47	2.85	A.
June	2,570	676	1,140	.717	.80	A.
July	6,480	402	1,120	.704	.81	A.
August	2,240	329	746	.469	.54	A.
September	29,800	270	2,640	1.66	1.85	A.
October	2,000	578	900	.566	.65	A.
November	9,390	686	1,360	.855	.95	A.
December	9,760	645	1,230	.774	.89	A.
The year	29,800	270	2,010	1.26	17.16	
1913						
January	5,100	1,040	2,050	1.29	1.49	A.
February	2,920	860	1,350	.849	.88	A.
March	17,700	729	3,130	1.97	2.27	A.
April	29,800	1,220	4,440	2.79	3.11	A.
May	27,200	918	2,830	1.78	2.05	A.
June	6,480	750	1,970	1.24	1.38	A.
July	3,700	382	888	.558	.64	A.
August	470	165	310	.195	.22	B.
September	975	110	222	.140	.16	B.
October	2,400	172	553	.348	.40	A.
November	4,850	355	897	.564	.63	A.
December	6,190	425	1,060	.667	.77	A.
The year	29,800	110	1,640	1.03	14.00	
1914						
January	23,600	918	2,790	1.75	2.02	A.
February	7,380	1,560	2,320	1.46	1.52	A.
March	4,140	1,560	2,490	1.57	1.81	A.
April	11,600	1,040	2,540	1.60	1.78	A.
May	2,320	502	1,140	.717	.83	A.
June	2,080	260	523	.329	.37	A.
July	1,770	141	515	.326	.38	A.
August	1,420	74	275	.173	.20	B.
September	470	97	163	.103	.12	B.
October	3,490	92	386	.243	.28	B.
November	6,770	191	675	.425	.47	A.
December	3,290	369	1,500	.943	1.09	A.
The year	23,600	74	1,270	.799	10.87	

JAMES RIVER BASIN.

JACKSON RIVER AT COVINGTON, VA.

Location.—At the footbridge leading to the West Virginia Pulp and Paper Co.'s mill, just above the Chesapeake & Ohio Railway bridge at Covington. Dunlap Creek enters a few hundred yards below the railroad bridge.

Drainage area.—440 square miles.

Records available.—May 11, 1907, to July 31, 1908.

Gage.—Chain gage on downstream side of footbridge.

Discharge measurements.—Made from the footbridge.

Channel and control.—Right bank low and liable to overflow; left bank high. Bed is composed of gravel and is practically permanent.

Extremes of discharge.—Maximum stage recorded: 6.85 feet, January 12, 1908; discharge not computed. Minimum stage recorded: 0.32 foot, July 21, 1908; discharge, 236 second-feet.

Winter flow.—Ice was present during winter of 1907-8, but did not materially affect the discharge relation.

Accuracy.—Results good for low and medium stages. Rating curve not developed for high stages.

Coöperation.—Station maintained by United States Geological Survey in coöperation with the United States Forest Service.

Discharge measurements of Jackson River at Covington, Va., in 1907.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
May 11....	R. J. Taylor.........	1.80	924	July 17...	R. G. Knight.......	.61	359
June 26 ...	R. G. Knight.......	2.60	1,820	July 25...	.....do................	.55	285

Daily gage height, in feet, of Jackson River at Covington, Va., for 1907–8.

[James E. Steeley, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	0.80	1.15	0.58	0.50	0.68	0.40	1.30
2	......	......	......	......	......	3.72	1.02	.48	.40	.60	.40	1.22
3	......	......	......	......	......	2.45	1.00	.40	.40	.48	2.60	1.12
4	......	......	......	......	......	1.95	.92	.35	.60	.50	1.80	1.02
5	......	......	......	......	......	1.90	.85	.38	.95	.50	1.45	.90
6	......	......	......	......	......	1.80	.80	.42	.72	.45	1.22	.85
7	......	......	......	......	......	1.50	.80	.60	.50	.45	1.15	.80
8	......	......	......	......	......	2.33	.78	.48	.50	.55	1.02	.75
9	......	......	......	......	......	3.52	.72	.48	.50	1.48	.95	.75
10	......	......	......	......	......	2.50	.95	.55	.50	1.15	1.10	2.30
11	......	......	......	......	1.80	2.60	.80	.80	.65	.98	2.35	3.70
12	......	......	......	......	1.65	3.25	.78	.75	.88	.82	1.88	2.62
13	......	......	......	......	1.48	4.23	.78	.65	.85	.75	1.55	2.08
14	......	......	......	......	1.38	6.50	.75	.52	.68	.62	1.40	1.92
15	......	......	......	......	1.28	4.23	.70	.48	.60	.58	1.22	1.75
16	......	......	......	......	1.22	3.00	.68	.42	.48	.52	1.15	1.62
17	......	......	......	......	1.20	2.35	.60	.48	.45	.50	1.00	1.48
18	......	......	......	......	1.12	2.00	.72	.40	.50	.45	1.00	1.85
19	......	......	......	......	1.10	1.75	1.02	.38	.50	.45	1.62	1.28
20	......	......	......	......	1.05	1.65	.90	.30	.50	.45	1.75	1.20
21	......	......	......	......	.95	1.48	.85	.30	.55	.40	1.62	1.15
22	......	......	......	......	.88	1.55	.78	.45	.50	.40	1.68	1.15
23	......	......	......	......	.82	2.30	.62	.45	1.62	.40	1.78	3.30
24	......	......	......	......	.80	2.02	.60	.92	2.00	.38	3.05	4.85
25	......	......	......	......	.78	2.73	.58	.80	1.45	.35	2.75	3.30
26	......	......	......	......	.80	2.45	.50	1.32	1.15	.35	2.28	2.45
27	......	......	......	......	.82	1.90	.50	1.05	.92	.35	1.95	2.12
28	......	......	......	......	.80	1.55	.45	.85	.85	.38	1.72	1.98
29	......	......	......	......	.78	1.38	.48	.72	.75	.40	1.55	1.95
30	......	......	......	......	.75	1.30	.82	.60	.75	.40	1.32	2.42
31	......	......	......	......	.75	......	.68	.52	......	.35	......	2.83
1908												
1	2.40	1.15	1.35	4.18	1.80	1.50	.62	......	......	......	......	......
2	2.12	1.05	2.35	3.45	1.75	1.30	.60	......	......	......	......	......
3	1.88	1.00	3.48	2.95	1.70	1.18	.55	......	......	......	......	......
4	1.78	1.20	2.98	2.48	1.58	1.58	.50	......	......	......	......	......
5	1.75	1.12	2.80	2.15	1.50	2.20	.80	......	......	......	......	......
6	1.58	1.10	4.67	1.95	1.48	1.85	.82	......	......	......	......	......
7	1.55	1.15	4.80	1.75	3.18	1.60	1.08	......	......	......	......	......
8	1.60	1.08	4.15	1.62	3.55	1.40	.88	......	......	......	......	......
9	1.52	.90	3.25	1.60	2.68	1.30	.78	......	......	......	......	......
10	1.25	1.10	2.87	1.52	2.40	1.28	.68	......	......	......	......	......
11	1.20	1.05	2.50	1.68	2.62	1.18	.60	......	......	......	......	......
12	6.85	1.30	2.32	1.75	2.22	1.20	.55	......	......	......	......	......
13	4.75	2.52	2.18	1.78	1.95	1.10	.48	......	......	......	......	......
14	3.20	3.55	1.96	1.78	1.75	1.05	.45	......	......	......	......	......
15	2.42	7.00	1.80	......	1.62	1.08	.48	......	......	......	......	......
16	2.18	5.30	1.72	......	1.52	1.10	.40	......	......	......	......	......
17	2.00	3.85	1.75	1.90	1.45	.98	.35	......	......	......	......	......
18	1.85	2.60	2.05	1.85	1.48	.85	.35	......	......	......	......	......
19	1.70	2.82	2.52	1.80	1.50	.78	.35	......	......	......	......	......
20	1.55	2.10	2.60	1.68	1.78	.78	.85	......	......	......	......	......
21	1.50	1.82	2.30	1.55	1.72	.85	.32	......	......	......	......	......
22	1.52	1.75	2.15	1.42	1.92	.72	.40	......	......	......	......	......
23	1.65	1.65	2.02	1.85	2.30	.85	.52	......	......	......	......	......
24	1.60	1.60	2.02	1.30	2.10	.68	.45	......	......	......	......	......
25	1.40	1.48	1.87	1.35	1.92	.65	.68	......	......	......	......	......

Daily gage height, in feet, of Jackson River at Covington, Va., for 1907–8—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
26	1.45	1.50	1.70	2.40	1.80	.70	.55	....	....	....	....	....
27	1.82	1.58	1.60	2.00	1.80	.88	1.15	....	....	....	....	....
28	1.65	1.48	1.55	1.75	1.88	.70	1.32	....	....	....	....	....
29	1.58	1.38	1.55	1.60	2.52	.60	.92	....	....	....	....	....
30	1.38	....	1.55	1.50	1.95	.58	.68	....	....	....	....	....
31	1.25	....	3.22	....	1.75	....	.62	....	....	....	....	....

Daily discharge, in second-feet, of Jackson River at Covington, Va., for 1907–8.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	....	....	....	....	....	390	540	314	290	348	260	615
2	....	....	....	....	....	....	479	284	260	320	260	575
3	....	....	....	....	....	1,610	470	260	260	284	1,800	525
4	....	....	....	....	....	1,080	438	245	320	290	955	479
5	....	....	....	....	....	1,040	410	254	450	290	708	430
6	....	....	....	....	....	955	390	266	362	275	575	410
7	....	....	....	....	....	740	390	320	290	275	540	390
8	....	....	....	....	....	1,470	383	284	....	305	479	372
9	....	....	....	....	....	....	362	284	....	727	450	372
10	....	....	....	....	....	1,670	450	305	290	540	515	1,440
11	....	....	....	....	955	1,800	390	390	338	462	1,490	....
12	....	....	....	....	845	....	383	372	422	398	1,020	1,820
13	....	....	....	....	727	....	383	338	410	372	775	1,210
14	....	....	....	....	663	....	372	296	348	327	675	1,050
15	....	....	....	....	605	....	355	284	320	314	575	918
16	....	....	....	....	575	2,360	348	266	284	296	540	824
17	....	....	....	....	565	1,490	320	284	275	290	470	727
18	....	....	....	....	525	1,130	362	260	290	275	470	645
19	....	....	....	....	515	918	479	254	290	275	824	605
20	....	....	....	....	492	845	430	280	290	275	918	565
21	....	....	....	....	450	727	410	230	305	260	824	540
22	....	....	....	....	422	775	383	275	290	260	866	540
23	....	....	....	....	398	1,440	327	275	824	260	940	....
24	....	....	....	....	390	1,150	320	438	1,130	254	....	....
25	....	....	....	....	383	1,970	314	390	708	245	2,000	....
26	....	....	....	....	390	1,610	290	627	540	245	1,410	1,610
27	....	....	....	....	398	1,040	290	492	438	245	1,080	1,240
28	....	....	....	....	390	775	275	410	410	254	895	1,110
29	....	....	....	....	383	663	284	362	372	260	775	1,080
30	....	....	....	....	372	615	398	320	372	260	627	1,570
31	....	....	....	....	372	....	348	296	....	245	....	2,110
1908												
1	1,550	540	645	....	955	740	327	....	....	....	....	....
2	1,240	492	1,490	....	918	615	320	....	....	....	....	....
3	1,020	470	....	2,280	880	555	305	....	....	....	....	....
4	940	565	2,330	1,650	796	796	290	....	....	....	....	....
5	918	525	2,060	1,280	740	1,320	390	....	....	....	....	....
6	796	515	....	1,080	727	995	398	....	....	....	....	....
7	775	540	....	918	....	810	506	....	....	....	....	....
8	810	506	....	824	....	675	422	....	....	....	....	....
9	754	430	....	810	1,900	615	383	....	....	....	....	....
10	590	515	2,170	754	1,550	605	348	....	....	....	....	....

Daily discharge, in second-feet, of Jackson River at Covington, Va., for 1907–8—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
11	565	492	1,670	866	1,820	555	320	....	....	....	....	....
12	....	615	1,460	918	1,350	565	305	....	....	....	....	....
13	....	1,700	1,300	940	1,080	515	284	....	....	....	....	....
14	....	....	1,080	940	918	492	275	....	....	....	....	....
15	1,570	....	955	970	824	506	284	....	....	....	....	....
16	1,300	....	895	1,010	754	515	260	....	....	....	....	....
17	1,130	....	918	1,040	708	462	245	....	....	....	....	....
18	995	1,800	1,180	995	727	410	245	....	....	....	....	....
19	880	1,460	1,700	955	740	383	245	....	....	....	....	....
20	775	1,220	1,800	866	940	383	245	....	....	....	....	....
21	740	971	1,440	775	895	410	236	....	....	....	....	....
22	754	918	1,280	688	1,050	362	260	....	....	....	....	....
23	845	845	1,150	645	1,440	410	296	....	....	....	....	....
24	810	810	1,150	615	1,220	348	275	....	....	....	....	....
25	675	727	1,010	645	1,050	338	348	....	....	....	....	....
26	708	740	880	1,550	955	355	305	....	....	....	....	....
27	971	796	810	1,130	955	422	540	....	....	....	....	....
28	845	727	775	918	1,020	355	627	....	....	....	....	....
29	796	663	775	810	1,700	320	438	....	....	....	....	....
30	663	....	775	740	1,080	314	348	....	....	....	....	....
31	590	....	....	....	918	....	327	....	....	....	....	....

NOTE.—Daily discharge for 1907 and 1908 based on a well-defined rating curve. The discharge was greater than 2,500 second-feet for all days, for which record is missing from May 11, 1907, to July 31, 1908.

JAMES RIVER AT BUCHANAN, VA.

Location.—At highway bridge near Chesapeake & Ohio Railway depot at Buchanan.

Drainage area.—2,060 square miles.

Records available.—August 18, 1895, to December 31, 1914.

Gage.—Chain gage on bridge; prior to November 21, 1903, wire gage; datum unchanged since April 3, 1897, when gage was lowered 2 feet to avoid negative readings; gage heights taken previous to that date, as published in "Hydrography of Virginia," Bulletin III, have been reduced to present datum.

Discharge measurements.—Made from bridge.

Channel and control.—Both banks high and clean and not likely to overflow except in extreme floods. Bed composed of rock overlain with mud. Rock control several hundred feet below station, but plotting of discharge measurements indicates that it has not remained permanent.

Extremes of discharge.—Maximum stage: 31.0 feet, crest of flood of March 27-28, 1913, determined by levelling to flood marks; discharge not computed. Minimum stage recorded: 1.2 feet in April and May, 1896; discharge, 260 second-feet; minimum estimates not very accurate.

Winter flow.—Discharge relation seldom seriously affected by ice.

Accuracy.—Well defined and fairly well defined rating curves for low and medium stages have been developed for different years according to the number of discharge measurements made. Above 20,000 second-feet the discharge estimates are more or less approximate.

Coöperation.—Station maintained by United States Geological Survey in coöperation with the United States Weather Bureau, which owns the gage and has furnished gage-height records since 1906.

Discharge measurements of James River at Buchanan, Va., in 1906–1915.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1906				1910			
June 12	H. D. Padgett	2.31	727	Sept. 6	G. C. Stevens	2.46	859
1907				1911			
May 9	R. J. Taylor	5.12	5,620	July 28	Mathers and Dean	1.88	421
June 24	R. G. Knight	4.44	3,870				
July 19	do	2.97	1,570	1912			
July 24	do	2.45	972	Nov. 21	Jackson and Batchelder	2.21	560
1909							
July 22	G. C. Stevens	2.26	690	1914			
Sept. 10	Stevens and Thomas	2.10	595	Oct. 2	Mathers and Morgan	1.98	334
				Oct. 2	do	1.98	336
				1915			
				June 25	H. J. Dean	2.76	861

Daily gage height, in feet, of James River at Buchanan, Va., for 1906–1914.

[D. D. Booze, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	3.64	4.13	2.45	6.24	3.2	2.7	2.25	2.6	4.3	5.4	3.3	3.2
2	3.42	3.88	2.35	5.42	3.1	2.61	2.21	2.5	3.8	5.0	3.2	3.1
3	3.39	3.56	2.55	4.95	3.14	2.59	2.25	2.5	3.6	4.8	3.1	3.0
4	7.9	3.42	4.21	4.42	2.96	2.4	4.22	2.5	3.3	8.0	3.0	2.9
5	7.08	3.34	5.39	4.35	3.02	2.31	2.96	2.3	3.1	9.1	3.0	2.9
6	5.49	3.2	4.22	4.0	3.45	2.72	2.72	2.3	3.0	7.1	2.9	2.8
7	4.72	3.19	3.91	4.05	3.55	2.64	2.45	3.6	2.9	6.2	2.9	2.8
8	4.18	3.09	3.55	3.84	3.4	2.52	2.3	3.3	2.7	5.4	2.8	2.7
9	3.93	2.9	3.52	3.8	3.36	2.51	2.26	3.3	2.6	4.8	2.8	2.7
10	3.55	2.94	3.28	4.28	3.12	2.34	2.2	3.0	2.5	4.3	2.7	2.6
11	3.39	2.93	3.24	4.92	3.1	2.3	2.19	2.8	2.6	3.9	2.7	2.7
12	3.33	2.7	3.01	4.46	2.94	2.34	2.12	2.7	2.5	3.6	2.8	2.7
13	3.39	2.77	3.01	4.25	2.91	2.3	2.22	2.9	2.8	3.4	2.8	2.7
14	3.55	2.75	2.85	3.9	2.7	2.45	2.31	3.4	3.6	3.2	2.8	2.7
15	3.55	2.65	3.38	4.48	2.78	2.4	2.32	3.6	3.0	3.1	2.7	2.7
16	3.81	2.72	7.0	5.5	2.65	2.4	2.3	4.5	2.8	3.0	2.7	2.7
17	3.86	2.66	5.9	5.01	2.8	2.35	2.3	4.5	2.7	3.0	2.7	2.7
18	3.79	2.49	4.83	4.4	2.9	2.55	2.2	4.2	3.1	8.0	2.7	7.3
19	3.62	2.5	4.59	4.25	2.96	2.5	2.2	4.0	3.0	9.8	2.9	6.6
20	3.41	2.5	4.67	3.92	2.76	4.12	2.2	3.8	3.0	15.6	6.9	5.6
21	3.35	2.4	4.89	3.85	2.78	4.75	2.9	3.8	2.9	10.7	7.4	5.2
22	3.46	2.5	4.63	3.6	2.6	3.96	2.7	3.7	3.0	7.3	5.8	4.8
23	9.41	2.52	4.65	3.59	2.66	3.58	2.6	4.1	3.0	5.7	4.9	4.4
24	9.16	2.45	4.28	3.4	2.49	3.16	2.4	4.3	3.1	5.2	4.4	4.2
25	6.34	2.55	4.23	3.38	2.5	2.92	2.3	4.1	3.1	4.8	4.1	4.0
26	5.4	2.53	3.88	3.12	2.36	2.79	2.3	3.6	2.8	4.4	3.8	3.5
27	4.86	2.43	5.4	3.22	2.68	2.6	2.3	3.3	2.6	4.1	3.5	3.2
28	4.83	2.5	7.88	3.1	2.75	2.6	2.3	3.6	2.7	3.9	3.3	3.6
29	5.0	....	7.14	3.2	2.8	2.59	2.3	4.6	3.9	3.7	3.3	3.5
30	4.6	....	6.16	3.1	2.9	2.51	3.1	4.4	3.4	3.6	3.2	3.5
31	4.37	....	6.46	....	2.94	....	3.1	4.3	....	3.4	....	3.5
1907												
1	5.6	3.2	4.5	4.5	3.7	2.8	3.3	2.3	2.0	2.9	2.2	3.5
2	5.2	3.5	4.7	5.0	3.8	6.8	3.2	2.3	2.0	2.8	2.3	3.3
3	4.8	3.9	6.9	4.6	3.6	7.0	3.1	2.3	2.0	2.7	3.1	3.2
4	4.6	3.7	6.0	4.3	3.6	5.3	3.0	2.3	2.0	2.6	4.3	3.1
5	4.4	3.9	5.2	4.3	3.5	4.7	2.9	2.3	2.4	2.5	3.5	3.0
6	4.2	3.7	4.5	4.3	3.5	4.8	2.8	2.3	3.0	2.5	3.2	2.9
7	4.0	3.4	4.4	8.7	5.6	4.4	2.8	2.3	2.5	2.5	2.8	2.8
8	3.8	3.3	4.4	7.4	5.7	4.1	2.7	2.3	2.4	2.5	2.8	2.8
9	3.8	3.4	4.4	8.8	5.1	6.8	2.7	2.3	2.3	2.5	2.7	2.8
10	3.8	3.4	4.4	8.6	4.9	5.4	2.6	2.4	2.2	2.5	2.8	3.6
11	3.8	4.0	5.5	6.8	4.7	4.8	2.6	2.7	2.5	2.5	2.8	9.3
12	3.7	4.2	5.8	5.8	4.5	5.4	2.8	2.6	4.0	2.5	2.7	6.4
13	3.7	3.9	5.5	5.3	4.3	6.0	2.8	2.5	3.5	2.5	3.6	5.1
14	4.1	3.6	6.7	5.0	4.0	16.4	2.8	2.5	3.0	2.4	3.4	5.0
15	4.4	3.6	6.5	4.7	3.8	10.4	2.6	2.4	2.8	2.3	3.2	4.8
16	5.3	3.6	6.0	4.4	3.7	7.2	2.6	2.3	2.7	2.3	3.0	5.0
17	7.2	3.6	5.2	4.2	3.6	5.8	2.6	2.2	2.5	2.3	2.9	4.8
18	7.4	3.6	4.8	4.2	3.4	5.0	2.6	2.2	2.5	2.3	2.9	4.1
19	7.5	3.5	4.4	4.0	3.3	4.5	2.8	2.2	2.5	2.3	2.9	4.0
20	6.8	3.5	5.2	4.0	3.2	4.3	2.7	2.2	2.4	2.3	4.2	3.9
21	5.8	3.5	5.7	3.9	3.2	4.0	2.7	2.2	2.4	2.3	4.0	3.8
22	4.8	3.5	5.1	3.8	3.1	3.7	2.6	2.2	2.4	2.2	4.0	3.7
23	4.6	3.3	4.6	3.7	3.0	3.9	2.6	2.2	6.1	2.2	4.0	5.0
24	4.2	3.3	4.3	4.5	3.0	4.6	2.5	2.4	8.4	2.2	6.7	11.9
25	4.0	3.3	3.9	5.3	2.9	4.6	2.4	2.7	5.3	2.2	7.7	8.0

Daily gage height, in feet, of James River at Buchanan, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	3.8	3.5	3.8	4.8	2.9	4.5	2.4	3.2	4.3	2.2	6.0	6.2
27	3.6	3.9	3.7	4.5	2.9	4.1	2.4	3.0	3.5	2.2	5.0	5.3
28	3.5	3.9	3.6	4.3	2.9	3.8	2.3	2.6	3.2	2.2	4.5	4.8
29	3.3	....	3.5	4.1	2.9	3.5	2.3	2.4	3.0	2.2	4.0	4.5
30	3.2	....	3.4	3.8	2.9	3.3	2.3	2.3	2.9	2.2	3.8	4.6
31	3.2	....	3.3	....	2.8	....	2.8	2.3	....	2.2	....	6.6
1908												
1	6.0	4.0	4.0	9.5	4.2	4.4	2.6	2.6	2.7	2.2	4.1	2.7
2	5.2	3.7	4.0	9.4	4.2	3.7	2.8	2.5	2.6	2.2	3.7	2.6
3	4.7	3.3	4.6	7.8	4.2	3.5	2.7	2.4	2.5	2.2	3.4	2.6
4	4.3	3.4	5.9	6.6	4.2	3.9	2.7	2.3	2.4	2.1	3.2	2.5
5	4.3	3.5	6.0	5.6	4.1	5.6	3.3	2.3	2.3	2.1	3.0	2.5
6	4.2	3.5	6.7	5.1	4.1	5.5	3.6	2.2	3.7	2.1	2.8	2.5
7	4.2	3.5	8.6	4.7	4.2	4.7	3.7	2.2	3.0	2.1	2.7	2.5
8	5.5	3.6	8.0	4.4	10.3	4.3	3.5	2.2	2.7	2.0	2.7	2.5
9	5.0	3.5	6.8	4.2	7.1	3.9	3.2	2.5	2.6	2.0	2.6	3.4
10	4.4	3.4	6.1	4.1	5.8	3.7	3.0	2.8	2.5	2.1	2.6	3.3
11	4.0	3.4	5.4	4.1	5.7	3.5	2.8	3.2	2.4	2.4	2.5	3.1
12	8.6	3.4	5.0	4.2	5.0	3.6	2.6	3.0	2.3	2.8	2.4	3.5
13	16.7	4.5	4.8	4.2	4.6	3.9	2.5	2.8	2.3	2.6	2.4	4.8
14	9.2	7.5	4.6	4.2	4.3	3.4	2.5	2.5	2.3	2.4	2.3	4.2
15	6.8	11.0	4.4	4.0	4.0	3.3	2.4	2.4	2.2	2.3	2.3	3.8
16	5.9	18.3	4.2	4.0	4.0	3.9	2.4	2.4	2.2	2.2	2.3	3.4
17	5.4	8.7	4.2	4.3	3.8	3.6	2.3	2.4	2.2	2.2	2.2	3.3
18	5.0	6.7	4.6	4.2	3.8	3.3	2.3	2.4	2.2	2.2	2.5	3.2
19	4.6	5.7	5.0	4.2	4.2	3.1	2.3	2.3	2.2	2.1	3.9	3.1
20	4.4	5.3	6.7	4.1	5.2	3.1	2.3	2.3	2.1	2.1	4.0	3.0
21	4.2	4.9	5.7	4.1	5.3	3.0	2.3	2.2	2.1	2.1	4.0	3.0
22	4.2	4.5	5.4	3.9	5.3	3.0	2.3	2.1	2.1	2.1	3.6	3.0
23	4.1	4.2	5.2	3.8	6.0	2.9	2.3	2.3	2.1	2.1	3.4	3.0
24	4.0	4.1	5.2	3.7	6.6	2.8	2.4	2.1	2.1	4.0	3.2	3.0
25	4.0	4.0	5.2	3.7	5.6	2.8	2.3	2.1	2.0	5.5	3.1	3.3
26	4.0	4.0	4.9	3.8	4.9	2.7	2.3	4.4	2.0	4.0	3.0	3.8
27	4.0	4.4	4.7	3.8	4.4	2.8	2.7	4.0	2.0	3.6	2.9	4.5
28	4.1	4.2	4.3	3.8	4.7	2.8	4.3	3.8	2.0	3.8	2.8	4.1
29	4.3	4.1	4.2	3.8	4.4	2.7	3.6	3.4	2.2	4.1	2.8	4.4
30	4.1	....	4.2	3.8	5.4	2.6	3.1	3.0	2.2	6.5	2.7	5.0
31	4.1	....	4.2	....	4.6	....	2.7	2.8	....	4.5	....	6.6
1909												
1	6.8	3.5	4.7	4.3	4.4	4.2	3.8	2.3	2.0	2.0	2.1	2.1
2	5.6	3.5	4.3	4.0	6.1	5.0	3.9	2.4	2.0	2.0	2.1	2.1
3	4.9	3.5	4.0	3.8	5.5	4.7	3.7	2.4	2.0	2.0	2.1	2.1
4	4.4	3.4	4.5	3.7	5.0	4.4	3.2	2.4	2.0	2.0	2.1	2.0
5	4.6	3.3	4.8	3.5	4.6	4.4	2.9	2.3	2.0	2.0	2.1	2.0
6	8.6	3.2	4.4	3.5	4.2	4.8	2.8	2.2	2.0	2.0	2.1	2.0
7	6.6	3.2	4.4	3.4	3.9	4.4	3.3	2.8	2.0	2.0	2.1	2.0
8	6.5	3.2	4.6	3.4	3.9	4.0	3.9	2.6	2.0	2.0	2.1	2.1
9	5.0	3.2	5.2	3.3	3.9	4.5	3.3	2.3	2.0	2.0	2.1	2.1
10	4.6	4.9	5.2	3.2	3.9	4.5	3.0	2.2	2.1	1.9	2.1	2.2
11	4.2	9.1	5.2	3.1	6.7	4.3	2.9	2.2	2.1	1.9	2.1	2.2
12	4.0	6.3	4.8	3.1	5.5	4.2	2.8	2.2	2.1	3.8	2.1	2.2
13	3.8	5.5	4.8	3.0	4.7	3.8	2.7	2.1	2.1	3.8	2.2	2.3
14	3.6	5.0	4.5	10.8	4.4	3.6	2.6	2.1	2.1	2.8	2.2	4.6
15	3.6	4.8	4.3	13.0	4.1	3.4	2.6	2.3	2.1	2.6	2.2	5.0
16	4.3	4.8	4.1	7.0	3.9	3.3	2.6	2.7	2.0	2.4	2.1	4.0
17	6.6	5.3	3.9	6.0	3.7	3.2	2.5	2.6	2.0	2.3	2.1	3.5
18	6.0	5.1	3.8	5.3	3.5	3.5	2.4	2.6	4.8	2.3	2.1	3.1
19	5.5	4.6	3.7	4.8	3.3	3.2	2.4	2.4	4.0	2.3	2.1	2.8
20	5.1	4.8	3.6	4.4	3.7	3.1	2.3	2.3	2.7	2.2	2.1	2.6

Daily gage height, in feet, of James River at Buchanan, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	5.4	4.8	3.6	4.0	3.8	3.0	2.3	2.2	2.3	2.2	2.1	2.4
22	5.2	4.8	3.6	3.8	10.0	2.9	2.2	2.2	2.3	2.1	2.1	2.3
23	5.8	4.9	3.5	4.2	7.5	2.8	2.3	2.2	2.2	2.1	2.1	2.3
24	6.2	5.3	4.0	4.8	6.0	2.8	2.2	2.1	2.2	2.1	2.1	2.3
25	6.1	6.5	4.4	5.3	5.0	2.7	2.2	2.1	2.2	2.2	2.1	2.6
26	5.6	6.0	7.5	4.8	6.7	2.9	2.2	2.0	2.2	2.2	2.1	2.2
27	4.9	5.4	6.0	4.4	8.2	3.0	2.2	2.0	2.1	2.2	2.1	2.3
28	4.5	5.0	5.0	4.0	6.7	2.9	2.2	2.0	2.1	2.2	2.1	2.3
29	4.0	....	5.0	4.0	5.8	2.8	2.2	2.0	2.1	2.2	2.1	2.3
30	3.8	....	4.8	3.9	5.0	2.7	2.3	2.0	2.0	2.2	2.1	2.2
31	3.6	....	4.5	....	4.4	....	2.3	2.0	....	2.2	....	2.2
1910												
1	2.1	3.0	4.9	2.6	3.6	2.6	3.2	2.5	2.0	2.0	2.0	1.9
2	2.3	2.9	7.1	2.6	3.5	2.6	3.0	2.5	2.0	2.0	2.0	1.9
3	2.4	2.9	6.0	2.6	3.3	2.5	2.9	2.5	2.0	1.9	2.0	2.0
4	2.4	3.2	5.8	2.7	3.2	2.5	2.9	2.4	2.7	1.9	2.0	2.0
5	3.1	3.8	4.9	3.1	3.1	2.5	2.9	2.4	3.0	1.9	2.0	2.0
6	3.3	3.6	4.5	3.2	3.3	2.6	3.2	2.3	2.5	1.9	2.0	2.0
7	4.9	3.3	4.3	3.0	2.9	2.9	3.2	2.3	2.3	1.9	1.9	2.0
8	6.2	3.0	4.1	2.9	3.0	3.1	3.1	2.3	2.3	2.0	1.9	2.0
9	4.6	3.2	4.0	2.8	3.1	2.9	3.0	2.3	2.2	2.2	1.9	2.0
10	3.9	3.1	3.8	2.7	3.0	2.8	4.0	2.2	2.2	2.3	1.9	2.0
11	3.7	3.0	3.7	2.7	3.0	4.3	3.4	2.2	2.1	2.2	1.9	2.0
12	3.5	3.0	3.6	2.7	2.9	6.7	3.2	2.2	2.1	2.1	1.9	2.0
13	3.3	2.9	3.4	2.9	2.9	10.8	3.1	2.1	2.1	2.1	1.9	2.0
14	3.3	2.8	3.4	4.3	2.8	15.6	3.0	2.1	2.0	2.0	1.9	1.9
15	3.2	3.0	3.4	3.8	2.8	9.8	3.0	2.1	2.0	2.0	1.9	1.9
16	3.1	3.2	3.3	3.6	2.8	10.5	3.1	2.1	2.0	2.0	1.9	1.9
17	2.9	4.3	3.2	3.8	2.8	14.4	5.0	2.1	2.0	1.9	1.9	1.9
18	2.7	7.8	3.1	4.8	2.8	9.3	5.6	2.1	2.0	1.9	1.9	1.9
19	2.7	7.9	3.1	5.3	2.8	6.8	8.4	2.1	2.0	1.9	1.9	2.0
20	3.9	5.6	3.0	4.9	2.7	6.0	5.8	2.1	1.9	2.0	1.9	2.0
21	3.7	5.3	3.0	4.5	2.7	5.3	4.6	2.1	1.9	2.1	1.9	2.0
22	3.7	4.9	3.0	4.2	2.7	5.1	4.0	2.1	1.9	2.1	1.9	2.0
23	6.4	4.6	2.9	3.9	2.7	4.9	3.7	2.1	1.9	2.3	1.9	2.0
24	5.3	4.4	2.9	3.7	2.7	4.3	3.5	2.1	1.9	2.4	1.9	2.0
25	4.3	4.2	2.8	3.6	2.7	4.2	3.3	2.1	1.9	2.3	1.9	2.2
26	3.8	4.1	2.8	3.6	3.1	4.0	3.1	2.1	1.9	2.2	1.9	2.5
27	3.7	3.9	2.7	3.6	3.0	3.7	3.0	2.1	1.9	2.1	1.9	2.5
28	3.5	3.8	2.7	3.8	2.9	3.5	2.8	2.1	1.9	2.1	1.9	2.7
29	3.3	....	2.7	3.9	2.8	3.5	2.7	2.1	1.9	2.1	1.9	2.9
30	3.1	....	2.7	3.8	2.7	3.4	2.6	2.0	2.0	2.0	1.9	3.4
31	3.0	....	2.6	....	2.6	....	2.5	2.0	....	2.0	....	3.7
1911												
1	4.0	7.5	3.0	5.2	3.6	2.5	2.1	1.8	4.8	2.0	2.6	3.0
2	6.6	5.6	3.0	5.0	3.6	2.5	2.1	1.8	4.4	2.0	2.5	2.9
3	9.0	4.8	3.0	5.0	3.5	2.4	2.1	1.8	3.4	2.1	2.4	2.8
4	11.0	4.0	3.0	5.9	3.4	2.4	2.1	1.8	2.9	2.1	2.4	2.7
5	6.7	3.8	2.9	8.0	3.3	2.5	2.1	1.9	2.7	2.1	2.3	2.7
6	5.7	3.5	2.9	9.6	3.2	2.5	2.1	2.2	2.5	2.1	2.3	2.6
7	4.5	3.3	6.5	8.2	3.2	3.1	2.1	2.2	2.3	2.0	3.9	2.6
8	3.9	4.3	5.1	8.2	3.1	3.2	2.7	2.0	2.3	2.0	3.7	2.6
9	3.6	4.6	4.8	8.0	3.1	3.0	2.7	2.0	2.2	2.0	4.5	2.5
10	3.3	5.2	5.5	7.8	3.0	2.9	2.5	1.9	2.2	2.0	4.0	2.5
11	3.1	5.1	7.0	7.6	3.0	2.8	2.5	1.9	2.4	2.0	3.8	2.5
12	3.0	4.6	6.1	7.6	2.9	2.7	2.5	1.9	2.9	2.3	3.6	2.5
13	3.0	4.2	5.4	7.0	2.8	2.6	2.4	1.9	2.9	2.3	3.5	2.5
14	2.9	4.0	5.1	7.2	2.8	2.5	2.4	1.8	2.6	2.3	3.5	2.4
15	2.9	3.8	5.3	6.9	2.7	2.4	2.4	1.8	2.4	2.3	3.5	2.4

Daily gage height, in feet, of James River at Buchanan, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
16	2.9	3.6	5.0	6.4	2.7	2.4	2.3	2.4	2.3	2.3	3.4	2.5
17	3.0	3.3	5.0	6.0	2.7	2.3	2.3	2.1	2.4	2.4	3.4	3.1
18	3.3	3.2	5.0	5.5	2.6	2.2	2.2	2.0	2.5	6.5	3.4	3.1
19	3.1	3.1	5.0	4.8	2.6	2.2	2.2	2.0	2.4	7.0	3.8	3.0
20	2.9	3.3	4.9	5.0	2.5	2.2	2.1	1.9	2.3	6.5	3.3	3.0
21	2.8	3.6	4.8	5.6	2.5	2.2	2.1	1.9	2.3	6.0	3.5	3.0
22	2.8	3.2	4.6	5.1	2.4	2.2	2.0	1.9	2.2	5.0	3.3	2.9
23	3.0	3.2	4.2	4.9	2.4	2.2	2.0	1.9	2.2	5.0	3.3	5.0
24	5.4	3.1	4.0	4.5	2.4	2.1	2.0	1.9	2.1	4.4	3.2	6.5
25	4.8	3.1	3.7	4.2	2.4	2.1	2.0	1.8	2.0	3.9	3.2	5.7
26	4.1	3.0	3.7	4.0	2.4	2.1	1.9	1.8	2.0	3.6	3.1	5.5
27	3.5	3.0	4.2	3.9	2.4	2.1	1.9	2.0	2.0	3.3	3.1	5.0
28	3.3	3.0	4.7	3.7	2.5	2.1	1.9	2.0	2.0	3.1	3.1	4.7
29	3.2	....	4.7	3.6	2.5	2.1	1.9	2.1	2.0	2.9	3.1	4.6
30	7.2	....	5.0	3.6	2.5	2.1	1.8	4.0	2.0	2.7	3.1	4.5
31	10.6	....	....	....	2.4	....	1.8	4.9	....	2.6	....	4.6
1912												
1	4.7	5.0	4.8	6.7	3.8	3.0	3.6	2.1	1.9	2.2	2.0	2.0
2	5.0	4.5	4.5	6.7	3.7	2.9	3.8	2.1	1.9	2.1	2.0	2.0
3	4.8	4.2	4.3	8.0	3.6	2.9	3.4	2.1	1.9	2.1	2.0	2.0
4	4.6	4.0	4.0	6.9	3.4	2.8	3.0	2.1	1.8	2.0	2.0	2.0
5	4.2	3.8	3.9	6.2	3.3	2.7	2.9	2.1	1.8	2.0	2.0	2.0
6	3.6	3.7	3.8	5.4	3.5	2.7	3.0	2.0	1.8	2.0	2.0	2.2
7	3.2	3.6	3.7	5.1	4.2	2.6	3.0	2.0	1.8	2.0	2.6	2.4
8	3.0	3.4	3.6	4.8	4.0	2.6	2.9	2.0	1.8	2.0	5.3	2.5
9	3.0	3.3	4.3	4.5	3.8	2.5	2.8	2.0	1.8	1.9	4.5	2.4
10	3.0	3.2	5.2	4.2	3.6	2.5	2.7	2.0	1.8	1.9	3.7	2.3
11	3.4	3.1	4.9	4.0	3.4	2.4	2.7	2.0	1.9	1.9	3.1	2.2
12	3.3	3.0	4.6	3.9	8.4	2.4	2.9	2.0	1.9	1.9	2.9	2.2
13	3.2	2.9	6.9	3.7	10.6	2.4	2.8	2.0	1.9	1.9	2.7	2.2
14	3.1	2.8	7.6	3.6	8.0	2.3	2.7	2.0	1.8	1.9	2.6	2.2
15	3.0	2.8	7.3	3.5	6.0	2.3	2.7	1.9	1.8	2.0	2.5	2.1
16	3.0	2.7	14.4	3.5	7.3	2.3	2.6	1.9	1.8	2.0	2.4	2.1
17	3.0	2.7	9.0	3.4	10.8	2.3	2.6	1.9	1.8	2.0	2.3	2.1
18	2.9	2.7	6.7	3.4	7.6	2.3	2.5	1.9	1.8	2.0	2.3	2.1
19	3.0	2.9	5.8	3.4	6.0	2.3	2.4	1.9	2.1	2.0	2.2	2.1
20	3.3	2.9	5.3	4.0	5.6	2.5	2.4	1.9	2.0	2.0	2.2	2.1
21	3.8	3.3	5.1	3.9	5.2	2.6	2.3	1.9	2.0	2.0	2.2	2.0
22	4.2	8.2	5.3	3.7	4.8	2.5	2.2	1.9	1.9	2.0	2.2	2.0
23	4.0	8.0	5.1	3.7	4.4	2.5	2.2	1.9	2.1	2.0	2.2	2.0
24	3.9	5.6	5.9	3.5	4.1	2.5	2.2	1.9	2.4	2.0	2.2	2.0
25	3.9	5.8	7.0	3.4	3.9	2.5	2.2	1.9	2.9	2.0	2.2	2.0
26	3.9	5.8	7.8	3.4	3.7	2.7	2.2	1.9	3.4	2.0	2.1	2.0
27	3.8	6.8	7.0	3.4	3.5	2.9	2.6	1.9	2.9	2.0	2.1	2.0
28	3.6	7.2	6.0	4.1	3.3	3.6	2.4	1.9	2.6	2.0	2.1	2.0
29	3.5	5.7	9.6	4.0	3.2	3.4	2.2	1.9	2.4	2.0	2.1	2.0
30	4.1	....	16.2	3.9	3.1	3.3	2.2	1.9	2.4	2.0	2.0	2.9
31	5.8	....	8.4	....	3.0	....	2.2	1.9	....	2.0	....	6.1
1913												
1	5.6	3.9	6.5	....	3.7	5.1	3.0	3.0	2.7	2.2	2.9	3.2
2	4.8	3.9	5.7	....	3.6	4.9	3.0	3.0	2.6	2.2	2.9	3.3
3	4.1	3.9	4.2	....	3.5	4.7	3.0	3.0	2.5	2.2	2.9	4.7
4	4.2	4.2	3.9	....	3.4	5.7	6.0	3.0	2.7	2.2	2.8	4.5
5	4.4	5.2	3.7	....	3.3	4.9	4.6	3.0	2.6	2.2	2.8	4.3
6	4.1	4.8	3.5	....	3.3	4.4	4.1	3.0	2.5	2.2	2.8	4.2
7	3.9	4.3	3.4	....	3.2	4.2	3.8	3.0	2.5	2.2	2.7	4.2
8	5.5	3.9	3.3	....	3.4	4.7	3.8	2.9	2.5	2.2	2.7	4.2
9	5.2	3.5	3.2	....	3.6	4.5	3.8	2.9	2.4	2.2	5.2	4.1
10	4.9	3.5	3.1	....	3.6	4.4	5.6	2.9	2.4	2.5	7.8	3.9

Daily gage height, in feet, of James River at Buchanan, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	4.4	3.3	4.0	....	3.4	4.2	4.6	2.9	2.4	2.8	4.8	3.7
12	4.1	3.3	4.8	....	3.3	4.0	4.1	3.7	2.4	2.8	4.8	3.5
13	3.9	3.2	4.4	....	3.2	3.7	3.7	3.8	2.4	2.8	4.7	3.4
14	3.7	3.0	9.1	....	3.2	3.4	3.6	3.7	2.4	2.8	4.7	3.3
15	3.5	2.8	12.0	....	3.2	3.2	3.5	3.6	2.4	2.7	4.6	3.2
16	3.4	2.8	10.5	....	3.1	3.1	3.4	3.5	2.1	2.6	4.7	3.2
17	3.3	2.8	7.6	....	3.4	3.0	3.4	3.5	2.1	2.6	5.7	3.1
18	3.3	2.8	6.5	....	3.5	3.0	3.3	3.5	2.1	2.6	5.6	3.1
19	3.2	2.7	5.6	....	3.5	3.0	3.3	3.4	2.1	2.6	5.0	3.0
20	3.1	2.7	4.8	....	3.5	3.0	3.3	3.4	2.1	2.9	4.5	3.0
21	3.0	2.7	4.5	....	3.5	3.0	3.6	3.4	2.9	3.4	4.1	3.0
22	2.9	2.7	4.3	4.6	3.7	3.0	3.5	3.3	2.7	3.9	3.8	2.9
23	2.9	2.6	4.1	4.4	4.2	3.2	3.4	3.3	2.7	3.7	3.6	2.9
24	2.9	2.6	3.9	4.2	8.0	3.0	3.3	3.2	2.6	3.5	3.4	3.0
25	2.9	2.6	3.8	4.1	7.2	3.0	3.3	3.2	2.5	3.8	3.3	3.2
26	2.8	2.7	3.8	4.0	5.7	3.2	3.2	3.1	2.4	5.8	3.2	3.7
27	2.8	3.3	11.3	3.9	5.1	3.5	3.1	3.1	2.4	4.5	3.2	6.3
28	5.5	7.0	....	3.9	7.7	3.8	3.0	3.0	2.3	4.1	3.2	5.2
29	5.0	....	....	3.9	7.2	3.2	3.0	3.0	2.3	3.7	3.2	4.9
30	4.5	....	....	3.8	6.1	3.0	3.0	2.9	2.3	3.4	3.2	4.6
31	4.1	....	....	....	5.5	....	3.0	2.9	....	3.1	....	4.4
1914												
1	4.3	4.8	4.7	4.7	4.7	2.6	2.5	2.2	2.3	2.1	2.2	5.4
2	4.1	7.5	4.5	4.7	4.6	2.6	2.7	2.2	2.3	2.1	2.2	5.3
3	4.3	6.0	4.3	4.8	4.5	2.6	2.4	2.2	2.2	2.1	2.2	4.7
4	4.5	5.2	4.2	5.0	4.4	2.6	2.2	2.2	2.2	2.1	2.2	4.7
5	4.6	5.0	4.1	4.8	4.3	2.5	2.2	2.2	2.2	2.2	2.2	8.2
6	4.1	5.3	4.0	4.5	4.2	2.5	2.2	2.2	2.2	2.2	2.2	9.0
7	3.9	7.0	3.9	5.4	4.1	2.5	2.2	2.2	2.1	2.1	2.2	8.5
8	3.9	8.5	3.9	5.3	4.0	2.5	2.2	2.2	2.1	2.1	2.2	5.5
9	4.3	6.7	4.0	5.2	3.9	2.5	2.2	2.1	2.1	2.1	2.2	5.0
10	5.9	5.7	4.0	5.1	3.8	2.5	2.7	2.1	2.1	2.1	2.2	4.6
11	5.7	5.3	3.9	5.1	3.7	2.4	2.5	2.1	2.1	2.1	2.2	4.3
12	5.3	5.0	3.9	5.0	3.6	2.4	2.2	2.1	2.1	2.1	2.2	4.1
13	4.7	4.7	4.4	5.0	3.5	2.4	2.2	2.1	2.1	2.1	2.2	4.0
14	4.3	4.5	4.9	4.9	3.4	2.3	3.8	2.1	2.1	2.1	2.2	4.0
15	4.1	4.3	4.9	4.9	3.3	2.3	3.4	2.1	2.1	2.7	2.7	4.5
16	4.0	4.1	4.7	5.5	3.2	2.3	3.1	2.1	2.1	5.0	3.2	4.5
17	3.9	3.8	4.6	5.2	3.1	2.3	2.8	2.1	2.1	4.4	3.1	4.4
18	3.8	3.8	6.7	5.2	3.0	2.2	2.5	2.1	2.1	3.4	2.9	4.3
19	3.7	5.3	6.9	5.1	3.0	2.2	2.4	2.1	2.1	3.0	2.7	4.2
20	3.7	8.9	6.5	5.1	3.0	2.2	2.4	2.1	2.1	2.7	2.7	4.5
21	3.7	8.7	5.7	5.8	2.9	2.2	2.3	2.1	2.1	2.6	2.6	4.7
22	5.3	6.5	5.2	5.1	2.9	2.2	2.3	2.1	2.1	2.5	2.6	4.7
23	4.9	6.3	4.9	4.8	2.9	2.2	2.3	2.1	2.1	2.4	2.5	4.7
24	4.9	6.2	4.9	4.6	2.8	2.2	2.2	2.1	2.1	2.3	2.4	4.7
25	5.3	5.7	4.9	4.4	2.8	2.2	2.2	2.1	2.1	2.3	2.4	4.7
26	6.7	5.2	5.0	4.3	2.8	2.2	2.2	3.0	2.1	2.3	2.3	4.7
27	5.7	5.0	4.9	8.0	2.8	2.2	2.2	2.6	2.1	2.3	2.3	4.9
28	5.2	4.9	4.8	5.9	2.7	2.4	2.2	2.5	2.1	2.3	2.3	4.9
29	4.8	....	4.8	5.5	2.7	2.6	2.2	2.5	2.1	2.3	2.2	4.9
30	4.5	....	4.8	5.0	2.7	2.5	2.2	2.4	2.1	2.3	2.2	5.1
31	4.5	....	4.8	....	2.7	....	2.2	2.4	....	2.2	....	6.6

NOTE.—Discharge relation probably affected by ice Dec. 23-31. 1909. Span of bridge and gage destroyed by flood on night of Mar. 27. 1913. Crest of flood determined by levels Oct. 2, 1914, 31.0 feet. New gage installed Apr. 22. 1913.

Daily discharge, in second-feet, of James River at Buchanan, Va., for 1906–1914.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	2,360	3,270	787	3,070	1,670	1,040	615	985	3,610	6,020	1,820	1,670
2	2,000	2,790	698	6,060	1,530	946	583	885	2,640	5,100	1,670	1,530
3	1,950	2,220	885	5,000	1,590	925	615	835	2,290	4,660	1,530	1,400
4	12,800	2,000	3,430	3,860	1,850	740	3,450	835	1,820	13,100	1,400	1,280
5	10,400	1,880	5,990	3,710	1,430	664	1,350	655	1,530	16,800	1,400	1,280
6	6,230	1,670	3,450	3,020	2,040	1,060	1,060	655	1,400	10,400	1,280	1,160
7	4,490	1,660	2,840	3,110	2,210	977	787	2,290	1,280	7,970	1,280	1,160
8	3,370	1,520	2,210	2,710	1,960	855	655	1,820	1,040	6,020	1,160	1,040
9	2,880	1,280	2,160	2,640	1,900	845	623	1,820	935	4,660	1,160	1,040
10	2,210	1,320	1,790	3,570	1,560	689	575	1,400	835	3,610	1,040	935
11	1,950	1,310	1,730	4,930	1,530	655	568	1,160	935	2,820	1,040	1,040
12	1,860	1,040	1,410	3,940	1,320	689	519	1,040	835	2,290	1,160	1,040
13	1,950	1,120	1,410	3,510	1,290	655	591	1,280	1,160	1,960	1,160	1,040
14	2,210	1,100	1,220	2,820	1,040	787	664	1,960	2,290	1,670	1,160	1,040
15	2,210	988	1,940	3,980	1,130	740	672	2,290	1,400	1,530	1,040	1,040
16	2,660	1,060	10,100	6,250	990	740	655	4,020	1,160	1,400	1,040	1,040
17	2,750	998	7,210	5,130	1,160	697	655	4,020	1,040	1,400	1,040	1,040
18	2,620	825	4,730	3,820	1,280	885	575	3,410	1,530	1,400	1,040	11,000
19	2,320	835	4,210	3,510	1,350	835	575	3,020	1,400	19,500	1,280	9,030
20	1,980	835	4,390	2,860	1,110	3,250	575	2,640	1,400	47,000	9,850	6,480
21	1,890	740	4,860	2,730	1,130	4,560	1,280	2,640	1,280	23,200	11,300	5,560
22	2,060	835	4,300	2,290	935	2,940	1,040	2,460	1,400	11,000	6,960	4,660
23	18,000	855	4,340	2,270	998	2,260	935	3,210	1,400	6,720	4,880	3,820
24	17,100	787	3,570	1,960	825	1,610	740	3,610	1,530	5,560	3,820	3,410
25	8,340	885	3,470	1,940	835	1,300	655	3,210	1,530	4,660	3,210	3,020
26	6,020	865	2,790	1,560	706	1,140	655	2,290	1,160	3,820	2,640	2,120
27	4,800	768	6,020	1,700	1,020	935	655	1,820	935	3,210	2,120	1,670
28	4,730	835	12,800	1,530	1,100	935	655	2,290	1,040	2,820	1,820	2,290
29	5,700	....	10,500	1,670	1,160	925	655	4,240	2,820	2,460	1,820	2,120
30	4,240	....	7,870	1,530	1,280	845	1,530	3,820	1,960	2,290	1,670	2,120
31	3,750	....	8,650	....	1,320	....	1,530	3,610	....	1,960	....	2,120
1907												
1	6,680	1,890	4,200	4,200	2,680	1,340	2,040	825	585	1,470	740	2,340
2	5,700	2,340	4,610	5,260	2,850	9,680	1,890	825	585	1,340	825	2,040
3	4,820	3,030	9,950	4,400	2,500	10,200	1,740	825	585	1,220	1,740	1,890
4	4,400	2,680	7,600	3,800	2,500	5,930	1,600	825	585	1,120	3,800	1,740
5	4,000	3,030	5,700	3,800	2,340	4,610	1,470	825	915	1,010	2,340	1,600
6	3,600	2,680	4,200	3,800	2,340	4,820	1,340	825	1,600	1,010	1,890	1,470
7	3,220	2,180	4,000	15,400	6,630	4,000	1,340	825	1,010	1,010	1,340	1,340
8	2,850	2,040	4,000	11,300	6,870	3,400	1,220	825	915	1,010	1,340	1,340
9	2,850	2,180	4,000	15,800	5,480	9,680	1,220	825	825	1,010	1,220	1,340
10	2,850	2,180	4,000	15,100	5,040	6,160	1,120	915	740	1,010	1,340	2,500
11	2,850	3,220	6,390	9,680	4,610	4,820	1,120	1,220	1,010	1,010	1,340	17,600
12	2,680	3,600	7,110	7,110	4,200	6,160	1,340	1,120	3,220	1,010	1,220	8,620
13	2,680	3,030	6,390	5,930	3,800	7,600	1,340	1,010	2,340	1,010	2,500	5,480
14	3,400	2,500	9,410	5,260	3,220	51,400	1,340	1,010	1,600	915	2,180	5,260
15	4,000	2,500	8,880	4,610	2,850	21,900	1,120	915	1,340	825	1,890	4,820
16	5,930	2,500	7,600	4,000	2,680	10,800	1,120	825	1,220	825	1,600	5,260
17	10,800	2,500	5,700	3,600	2,500	7,110	1,120	740	1,010	825	1,470	4,820
18	11,300	2,500	4,820	3,600	2,180	5,260	1,120	740	1,010	825	1,470	3,400
19	11,600	2,340	4,000	3,220	2,040	4,200	1,340	740	1,010	825	1,470	3,220
20	9,680	2,340	5,700	3,220	1,890	3,800	1,220	740	915	825	3,600	3,030
21	7,110	2,340	6,870	3,030	1,890	3,220	1,220	740	915	825	3,220	2,850
22	4,820	2,340	5,480	2,850	1,740	2,680	1,120	740	915	740	3,220	2,680
23	4,400	2,040	4,400	2,680	1,600	3,030	1,120	740	7,850	740	3,220	5,260
24	3,600	2,040	3,800	4,200	1,600	4,400	1,010	915	14,400	740	9,410	28,400
25	3,220	2,040	3,030	5,930	1,470	4,400	915	1,220	5,930	740	12,200	13,100

Daily discharge, in second-feet, of James River at Buchanan, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	2,850	2,340	2,850	4,820	1,470	4,200	915	1,890	3,800	740	7,600	8,100
27	2,500	3,030	2,680	4,200	1,470	3,400	915	1,600	2,340	740	5,260	5,930
28	2,340	3,030	2,500	3,800	1,470	2,850	825	1,120	1,890	740	4,200	4,820
29	2,040	....	2,340	3,400	1,470	2,340	825	915	1,600	740	3,220	4,200
30	1,890	....	2,180	2,850	1,470	2,040	825	825	1,470	740	2,850	4,400
31	1,890	....	2,040	....	1,340	....	825	825	....	740	....	9,140
1908												
1	7,460	3,040	3,040	18,300	3,430	3,830	1,030	1,030	1,140	660	3,240	1,140
2	5,560	2,500	3,040	18,000	3,430	2,500	1,240	930	1,030	660	2,500	1,030
3	4,450	1,880	4,240	12,500	3,430	2,180	1,140	835	930	660	2,030	1,030
4	3,630	2,030	7,210	9,030	3,430	2,860	1,140	745	835	585	1,740	930
5	3,630	2,180	7,460	6,480	3,240	6,480	1,880	745	745	585	1,480	930
6	3,430	2,180	9,300	5,330	3,240	6,250	2,340	660	2,500	585	1,240	930
7	3,430	2,180	15,100	4,450	3,430	4,450	2,500	660	1,480	585	1,140	930
8	6,250	2,340	18,100	3,820	21,500	3,630	2,180	660	1,140	515	1,140	930
9	5,100	2,180	9,580	3,430	10,400	2,860	1,740	930	1,030	515	1,030	2,030
10	3,830	2,030	7,720	3,240	6,960	2,500	1,480	1,240	930	585	1,030	1,880
11	3,040	2,030	6,020	3,240	6,720	2,180	1,240	1,740	835	835	930	1,610
12	15,100	2,030	5,100	3,430	5,100	2,340	1,030	1,480	745	1,240	835	2,180
13	53,000	4,030	4,660	3,430	4,240	2,860	930	1,240	745	1,030	835	4,660
14	17,200	11,600	4,240	3,430	3,630	2,030	930	930	745	835	745	3,430
15	9,580	24,400	3,830	3,040	3,040	1,880	835	835	660	745	745	2,680
16	7,210	62,000	3,430	3,040	3,040	2,860	835	835	660	660	745	2,030
17	6,020	15,400	3,430	3,630	2,680	2,340	745	835	660	660	660	1,880
18	5,100	9,300	4,240	3,430	2,680	1,880	745	835	660	660	930	1,740
19	4,240	6,720	5,100	3,430	3,430	1,610	745	745	660	660	2,860	1,610
20	3,830	5,780	9,300	3,240	5,560	1,610	745	745	585	585	3,040	1,480
21	3,430	4,880	6,720	3,240	5,780	1,480	745	660	585	585	3,040	1,480
22	3,430	4,030	6,020	2,860	5,780	1,480	745	585	585	585	2,340	1,480
23	3,240	3,430	5,560	2,680	7,460	1,360	745	745	585	585	2,030	1,480
24	3,040	3,240	5,560	2,500	9,030	1,240	835	585	585	3,040	1,740	1,480
25	3,040	3,040	5,560	2,500	6,480	1,240	745	585	515	6,250	1,610	1,880
26	3,040	3,040	4,880	2,680	4,880	1,140	745	3,820	515	3,040	1,480	2,680
27	3,040	3,830	4,450	2,680	3,820	1,240	1,140	3,040	515	2,340	1,360	4,030
28	3,240	3,430	3,630	2,680	4,450	1,240	3,620	2,680	515	2,680	1,240	3,240
29	3,630	3,240	3,430	2,680	3,830	1,140	2,340	2,030	660	3,240	1,240	3,820
30	3,240	....	3,430	2,680	6,020	1,030	1,610	1,480	660	8,760	1,140	5,100
31	3,240	....	3,430	....	4,240	....	1,140	1,240	....	4,030	....	9,030
1909												
1	9,580	2,180	4,450	3,620	3,820	3,430	2,680	745	515	515	585	585
2	6,480	2,180	3,620	3,040	7,720	5,100	2,860	835	515	515	585	585
3	4,880	2,180	3,040	2,680	6,250	4,450	2,500	835	515	515	585	585
4	3,820	2,030	4,030	2,500	5,100	3,820	1,740	835	515	515	585	515
5	4,240	1,880	4,660	2,180	4,240	3,820	1,360	745	515	515	585	515
6	15,100	1,740	3,820	2,180	3,430	4,660	1,240	660	515	515	585	515
7	9,030	1,740	3,820	2,030	2,860	3,820	1,880	1,240	515	515	585	515
8	8,760	1,740	4,240	2,030	2,860	3,040	2,860	1,030	515	515	585	585
9	5,100	1,740	5,560	1,880	2,860	4,030	1,880	745	515	515	585	585
10	4,240	4,880	5,560	1,740	2,860	4,030	1,480	660	585	450	585	660
11	3,430	16,800	5,560	1,610	9,300	3,620	1,360	660	585	450	585	660
12	3,040	8,230	4,660	1,610	6,250	3,430	1,240	660	585	2,680	585	660
13	2,680	6,250	4,660	1,480	4,450	2,680	1,140	585	585	2,680	660	745
14	2,340	5,100	4,030	23,600	3,820	2,340	1,030	585	585	1,240	660	4,240
15	2,340	4,660	3,620	33,600	3,240	2,030	1,030	745	585	1,030	660	5,100
16	3,620	4,660	3,240	10,100	2,860	1,880	1,030	1,140	515	835	585	3,040
17	9,030	5,780	2,860	7,460	2,500	1,740	930	1,030	515	745	585	2,180
18	7,460	5,330	2,680	5,780	2,180	2,180	835	1,030	4,660	745	585	1,610
19	6,250	4,240	2,500	4,660	1,880	1,740	835	835	3,040	745	585	1,240
20	5,330	4,660	2,340	3,820	2,500	1,610	745	745	1,140	660	585	1,030

Daily discharge, in second-feet, of James River at Buchanan, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	6,020	4,660	2,340	3,040	2,680	1,480	745	660	745	660	585	835
22	5,560	4,660	2,340	2,680	20,300	1,360	660	660	745	585	585	745
23	6,960	4,880	2,180	3,430	11,600	1,240	745	660	660	585	585	860
24	7,970	5,780	3,040	4,660	7,460	1,240	660	585	660	585	585	710
25	7,720	8,760	3,820	5,780	5,100	1,140	660	585	660	660	585	550
26	6,480	7,460	11,600	4,660	9,300	1,360	660	515	660	660	585	550
27	4,880	6,020	7,460	3,820	13,800	1,480	660	515	585	660	585	680
28	4,030	5,100	5,100	3,040	9,300	1,360	660	515	585	660	585	640
29	3,040	....	5,100	3,040	6,960	1,240	660	515	585	660	585	520
30	2,680	....	4,660	2,860	5,100	1,140	745	515	515	660	585	580
31	2,340	....	4,080	....	3,820	....	745	515	....	660	....	490
1910												
1	585	1,480	4,880	1,030	2,340	1,030	1,740	930	515	515	515	450
2	745	1,360	10,400	1,030	2,180	1,030	1,480	930	515	515	515	450
3	835	1,360	7,460	1,030	1,880	930	1,360	930	515	450	515	515
4	835	1,740	5,780	1,140	1,740	930	1,360	835	1,140	450	515	515
5	1,610	2,680	4,880	1,610	1,610	930	1,360	835	1,480	450	515	515
6	1,880	2,340	4,030	1,740	1,880	1,030	1,740	745	930	450	515	515
7	4,880	1,880	3,620	1,480	1,360	1,360	1,740	745	745	450	450	515
8	7,970	1,480	3,240	1,360	1,480	1,610	1,610	745	745	515	450	515
9	4,240	1,740	3,040	1,240	1,610	1,360	1,480	745	660	660	450	515
10	2,860	1,610	2,680	1,140	1,480	1,240	3,040	660	660	745	450	515
11	2,500	1,480	2,500	1,140	1,480	3,620	2,030	660	585	660	450	515
12	2,180	1,480	2,340	1,140	1,360	9,300	1,740	660	585	585	450	515
13	1,880	1,360	2,030	1,360	1,360	23,600	1,610	585	585	585	450	515
14	1,880	1,240	2,030	3,620	1,240	47,000	1,480	585	515	515	450	450
15	1,740	1,480	2,030	2,680	1,240	19,500	1,480	585	515	515	450	450
16	1,610	1,740	1,880	2,340	1,240	22,300	1,610	585	515	515	450	450
17	1,360	3,620	1,740	2,680	1,240	40,700	5,100	585	515	450	450	450
18	1,140	12,500	1,610	4,660	1,240	17,600	6,480	585	515	450	450	450
19	1,140	12,800	1,610	5,780	1,240	9,580	14,400	585	515	450	450	515
20	2,860	6,480	1,480	4,880	1,140	7,460	6,960	585	450	515	450	515
21	2,500	5,780	1,480	4,030	1,140	5,780	4,240	585	450	585	450	515
22	15,400	4,880	1,480	3,430	1,140	5,330	3,040	585	450	585	450	515
23	8,500	4,240	1,360	2,860	1,140	4,880	2,500	585	450	745	450	515
24	5,780	3,820	1,360	2,500	1,140	3,620	2,180	585	450	835	450	515
25	3,620	3,430	1,240	2,340	1,140	3,430	1,880	585	450	745	450	660
26	2,680	3,240	1,240	2,340	1,610	3,040	1,610	585	450	660	450	930
27	2,500	2,860	1,140	2,340	1,480	2,500	1,480	585	450	585	450	930
28	2,180	2,680	1,140	2,680	1,360	2,180	1,240	585	450	585	450	1,140
29	1,880	....	1,140	2,860	1,240	2,180	1,140	585	450	585	450	1,360
30	1,610	....	1,140	2,680	1,140	2,030	1,030	515	515	515	450	2,030
31	1,480	....	1,030	....	1,030	....	930	515	....	515	....	2,500
1911												
1	3,040	11,600	1,480	5,560	2,340	930	585	385	4,660	515	1,080	1,480
2	9,030	6,480	1,480	5,100	2,340	930	585	385	3,820	515	930	1,360
3	16,500	4,660	1,480	5,100	2,180	835	585	385	2,030	585	835	1,240
4	21,400	3,040	1,480	7,210	2,030	835	585	385	1,360	585	835	1,140
5	9,300	2,680	1,360	13,100	1,880	930	585	450	1,140	585	745	1,140
6	6,720	2,180	1,360	18,700	1,740	930	585	660	930	585	745	1,030
7	4,030	1,880	8,760	13,800	1,740	1,610	585	660	745	515	2,860	1,030
8	2,860	3,620	5,330	13,800	1,610	1,740	1,140	515	745	515	2,500	1,030
9	2,340	4,240	3,620	13,100	1,610	1,480	1,140	515	660	515	4,030	930
10	1,880	5,560	6,250	12,500	1,480	1,360	930	450	660	515	3,040	930
11	1,610	5,330	10,100	11,900	1,480	1,240	930	450	835	515	2,680	930
12	1,480	4,240	7,720	11,900	1,360	1,140	930	450	1,360	745	2,340	930
13	1,480	3,430	6,020	10,100	1,240	1,030	835	450	1,360	745	2,180	930
14	1,360	3,040	5,330	10,700	1,240	930	835	385	1,030	745	2,180	835
15	1,360	2,680	5,780	9,850	1,140	835	835	385	835	745	2,180	835

Daily discharge, in second-feet, of James River at Buchanan, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
16	1,360	2,340	5,100	8,500	1,140	835	745	835	745	745	2,080	980
17	1,480	1,880	5,100	7,460	1,140	745	745	585	835	835	2,080	1,610
18	1,880	1,740	5,100	6,250	1,080	660	660	515	930	8,760	2,080	1,610
19	1,610	1,610	5,100	4,660	1,030	660	660	515	835	10,100	1,880	1,480
20	1,360	1,880	4,880	5,100	930	660	585	450	745	8,760	1,880	1,480
21	1,240	2,340	4,660	6,480	930	660	585	450	745	7,460	2,180	1,480
22	1,240	1,740	4,240	5,330	835	660	515	450	660	5,100	1,880	1,360
23	1,480	1,740	3,430	4,880	835	660	515	450	660	5,100	1,880	5,100
24	6,020	1,610	3,040	4,080	835	585	515	450	585	3,820	1,740	8,760
25	4,660	1,610	2,500	3,430	835	585	515	385	515	2,860	1,740	6,720
26	3,240	1,480	2,500	3,040	835	585	450	385	515	2,340	1,610	6,250
27	2,180	1,480	3,430	2,860	835	585	450	515	515	1,880	1,610	5,100
28	1,880	1,480	4,450	2,500	930	585	450	515	515	1,610	1,610	4,450
29	1,740	....	4,450	2,340	930	585	450	585	515	1,360	1,610	4,240
30	10,700	....	5,100	2,340	930	585	385	3,040	515	1,140	1,610	4,030
31	22,700	....	5,330	....	835	....	385	4,880	....	1,030	....	4,240
1912												
1	4,450	5,100	4,660	9,300	2,680	1,480	2,340	520	385	600	450	450
2	5,100	4,030	4,030	9,300	2,500	1,360	2,680	520	385	520	450	450
3	4,660	3,430	3,620	13,100	2,340	1,360	2,030	520	385	520	450	450
4	4,240	3,040	3,040	9,850	2,030	1,240	1,480	520	325	450	450	450
5	3,430	2,680	2,860	7,970	1,880	1,120	1,360	520	325	450	450	450
6	2,340	2,500	2,680	6,020	2,180	1,120	1,480	450	325	450	450	600
7	1,740	2,340	2,500	5,330	3,430	1,000	1,480	450	325	450	1,000	790
8	1,480	2,030	2,340	4,660	3,040	1,000	1,360	450	325	450	5,780	890
9	1,480	1,880	3,620	4,030	2,680	890	1,240	450	325	385	4,080	790
10	1,480	1,740	5,560	3,430	2,340	890	1,120	450	325	385	2,500	690
11	2,030	1,610	4,880	3,040	2,030	790	1,120	450	385	385	1,610	600
12	1,880	1,480	4,240	2,860	14,400	790	1,360	450	385	385	1,360	600
13	1,740	1,360	9,850	2,500	22,700	790	1,240	450	385	385	1,120	600
14	1,610	1,240	11,900	2,340	13,100	690	1,120	450	325	385	1,000	600
15	1,480	1,240	11,000	2,180	7,460	690	1,120	385	325	450	890	520
16	1,480	1,120	40,700	2,180	11,000	690	1,000	385	325	450	790	520
17	1,480	1,120	16,500	2,030	23,600	690	1,000	385	325	450	690	520
18	1,360	1,120	9,300	2,030	11,900	690	890	385	325	450	690	520
19	1,480	1,360	6,960	2,030	7,460	690	790	385	520	450	600	520
20	1,880	1,360	5,780	3,040	6,480	890	790	385	450	450	600	520
21	2,680	1,880	5,330	2,860	5,560	1,000	690	385	450	450	600	450
22	3,430	13,800	5,780	2,500	4,660	890	600	385	385	450	600	450
23	3,040	13,100	5,330	2,500	3,820	890	600	385	520	450	600	450
24	2,860	6,480	7,210	2,180	3,240	890	600	385	790	450	600	450
25	2,860	6,960	10,100	2,030	2,860	890	600	385	1,360	450	600	450
26	2,860	6,960	12,500	2,030	2,500	1,120	600	385	2,030	450	520	450
27	2,680	9,580	10,100	2,030	2,180	1,360	1,000	385	1,360	450	520	450
28	2,340	10,700	7,460	3,240	1,880	2,340	790	385	1,000	450	520	450
29	2,180	6,720	18,700	3,040	1,740	2,030	600	385	790	450	520	450
30	3,240	....	50,300	2,860	1,610	1,880	660	385	790	450	450	1,360
31	6,960	....	14,400	....	1,480	....	600	385	....	450	....	7,720
1913												
1	6,480	2,820	8,760	....	2,460	5,330	1,400	1,400	1,040	515	1,280	1,670
2	4,660	2,820	6,720	....	2,290	4,880	1,400	1,400	930	515	1,280	1,820
3	3,210	2,820	3,410	....	2,120	4,450	1,400	1,400	820	515	1,280	4,450
4	3,410	3,410	2,820	....	1,960	6,720	7,460	1,400	1,040	515	1,160	4,020
5	3,820	5,560	2,460	....	1,820	4,880	4,240	1,400	930	515	1,160	3,610
6	3,210	4,660	2,120	....	1,820	3,820	3,210	1,400	820	515	1,160	3,410
7	2,820	3,610	1,960	....	1,670	3,410	2,640	1,400	820	515	1,040	3,410
8	6,250	2,820	1,820	....	1,960	4,450	2,640	1,280	820	515	1,040	3,410
9	5,560	2,120	1,670	....	2,290	4,020	2,640	1,280	715	515	5,560	3,210
10	4,880	2,120	1,580	....	2,290	3,820	6,480	1,280	715	820	12,500	2,820

Daily discharge, in second-feet, of James River at Buchanan, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	3,820	1,820	3,020	....	1,960	3,410	4,240	1,280	715	1,160	4,660	2,460
12	3,210	1,820	4,660	....	1,820	3,020	3,210	2,460	715	1,160	4,660	2,120
13	2,820	1,670	3,820	....	1,670	2,460	2,460	2,640	715	1,160	4,450	1,960
14	2,460	1,400	16,800	....	1,670	1,960	2,290	2,460	715	1,160	4,450	1,820
15	2,120	1,160	28,800	....	1,670	1,670	2,120	2,290	715	1,040	4,240	1,670
16	1,960	1,160	22,300	....	1,530	1,530	1,960	2,120	430	930	4,450	1,670
17	1,820	1,160	11,900	....	1,960	1,400	1,960	2,120	430	930	6,720	1,530
18	1,820	1,160	8,760	....	2,120	1,400	1,820	2,120	430	930	6,480	1,530
19	1,670	1,040	6,480	....	2,120	1,400	1,820	1,960	430	930	5,100	1,400
20	1,530	1,040	4,660	....	2,120	1,400	1,820	1,960	430	1,280	4,020	1,400
21	1,400	1,040	4,020	....	2,120	1,400	2,290	1,960	1,280	1,960	3,210	1,400
22	1,280	1,040	3,610	4,240	2,460	1,400	2,120	1,820	1,040	2,820	2,640	1,280
23	1,280	930	3,210	3,820	3,410	1,670	1,960	1,820	1,040	2,460	2,290	1,280
24	1,280	930	2,820	3,410	13,100	1,400	1,820	1,670	930	2,120	1,960	1,400
25	1,280	930	2,640	3,210	10,700	1,400	1,820	1,670	820	2,640	1,820	1,670
26	1,160	1,040	2,640	3,020	6,720	1,670	1,670	1,530	715	5,780	1,670	2,460
27	1,160	1,820	....	2,820	5,330	2,120	1,530	1,530	715	4,020	1,670	8,230
28	6,250	10,100	....	2,820	12,200	2,640	1,400	1,400	610	3,210	1,670	5,560
29	5,100	....	....	2,820	10,700	1,670	1,400	1,400	610	2,460	1,670	4,880
30	4,020	....	....	2,640	7,720	1,400	1,400	1,280	610	1,960	1,670	4,240
31	3,210	....	....	....	6,250	....	1,400	1,280	....	1,530	....	3,820
1914												
1	3,610	4,660	4,450	4,450	4,450	930	820	515	610	430	515	6,020
2	3,210	11,600	4,020	4,450	4,240	930	1,040	515	610	430	515	5,780
3	3,610	7,460	3,610	4,660	4,020	930	715	515	515	430	515	4,450
4	4,020	5,560	3,410	5,100	3,820	930	515	515	515	430	515	4,450
5	4,240	5,100	3,210	4,660	3,610	820	515	515	515	515	515	13,800
6	3,210	5,780	3,020	4,020	3,410	820	515	515	515	515	515	16,500
7	2,820	10,100	2,820	6,020	3,210	820	515	515	430	430	515	14,800
8	2,820	14,800	2,820	5,780	3,020	820	515	515	430	430	515	6,250
9	3,610	9,300	3,020	5,560	2,820	820	515	430	430	430	515	5,100
10	7,210	6,720	3,020	5,330	2,640	820	1,040	430	430	430	515	4,240
11	6,720	5,780	2,820	5,330	2,460	715	820	430	430	430	515	3,610
12	5,780	5,100	2,820	5,100	2,290	715	515	430	430	430	515	3,210
13	4,450	4,450	3,820	5,100	2,120	715	515	430	430	430	515	3,020
14	3,610	4,020	4,880	4,880	1,960	610	2,640	430	430	430	515	3,020
15	3,210	3,610	4,880	4,880	1,820	610	1,960	430	430	1,040	1,040	4,020
16	3,020	3,210	4,450	6,250	1,670	610	1,530	430	430	5,100	1,670	4,020
17	2,820	2,640	4,240	5,560	1,530	610	1,160	430	430	3,820	1,530	3,820
18	2,640	2,640	9,300	5,560	1,400	515	820	430	430	1,960	1,280	3,610
19	2,460	5,780	9,850	5,330	1,400	515	715	430	430	1,400	1,040	3,410
20	2,460	16,100	8,760	5,330	1,400	515	715	430	430	1,040	1,040	4,020
21	2,460	15,400	6,720	6,960	1,280	515	610	430	430	930	930	4,450
22	5,780	8,760	5,560	5,330	1,280	515	610	430	430	820	930	4,450
23	4,880	8,230	4,880	4,660	1,280	515	610	430	430	715	820	4,450
24	4,880	7,970	4,880	4,240	1,160	515	515	430	430	610	715	4,450
25	5,780	6,720	4,880	3,820	1,160	515	515	430	430	610	715	4,450
26	9,300	5,560	5,100	3,620	1,160	515	515	1,400	430	610	610	4,450
27	6,720	5,100	4,880	13,100	1,160	515	515	930	430	610	610	4,880
28	5,560	4,880	4,660	7,210	1,040	715	515	820	430	610	610	4,880
29	4,660	....	4,660	6,250	1,040	930	515	820	430	610	515	4,880
30	4,030	....	4,660	5,100	1,040	820	515	715	430	610	515	5,330
31	4,030	....	4,660	....	1,040	....	515	715	....	515	....	9,030

NOTE.—Discharge determined from several rating curves coincident above about 5,000 second-feet, but differing below that discharge on account of shifting control as indicated by the discharge measurements. Rating curves fairly well defined below and approximate above 20,000 second-feet.

Discharge Dec. 23-31, 1909, when discharge relation was probably affected by ice, estimated at about 28 per cent of that at Cartersville.

Monthly discharge of James River at Buchanan, Va., for 1895–1914.

[Drainage area, 2,060 square miles.]

Month	Discharge in second-feet: Maximum	Minimum	Mean	Per square mile	Run-off (depth in inches on drainage area)	Accuracy
1895						
August 25–31	530	475	506	.246	.064	
September	475	380	412	.200	.223	
October	425	425	425	.207	.239	
November	585	475	563	.274	.306	
December 1–28	5,260	530	1,189	.578	.602	
1896						
January 24–31	7,600	1,050	2,874	1.40	.417	
February	10,920	1,050	3,422	1.66	1.79	
March	22,950	1,050	4,712	2.29	2.64	
April	16,650	260	2,332	1.13	1.26	
May	2,065	260	1,035	.503	.580	
June	3,310	710	1,294	.629	.702	
July	30,000	785	2,990	1.42	1.64	
August	2,340	585	1,025	.498	.574	
September	40,160	475	1,826	.887	.990	
October	11,060	530	1,284	.624	.719	
November	17,200	530	2,527	1.23	1.37	
December	8,620	785	1,810	.879	1.01	
1897						
January	1,495	710	886	.431	.497	
February	38,600	1,260	10,560	5.13	5.34	
March	12,830	2,185	4,821	2.34	2.70	
April	3,600	1,150	2,064	1.00	1.12	
May	22,120	1,100	4,730	2.30	2.65	
June	1,750	710	1,018	.495	.552	
July	2,110	710	1,049	.510	.588	
August	955	530	621	.302	.348	
September	585	335	425	.207	.231	
October	502	295	394	.191	.220	
November	530	295	368	.179	.200	
December	1,558	475	1,052	.511	.589	
The year	38,600	295	2,332	1.13	15.04	
1898						
January	4,930	1,002	2,280	1.11	1.28	
February	2,035	865	1,226	.596	.621	
March	14,750	955	2,745	1.33	1.53	
April	10,500	1,620	4,235	2.06	2.30	
May	24,420	1,050	4,264	2.07	2.39	
June	1,495	645	904	.439	.490	
July	2,185	530	804	.391	.451	
August	26,820	785	4,064	1.97	2.27	
September	6,250	325	806	.392	.437	
October	39,120	505	4,163	2.02	2.33	
November	8,230	1,040	2,212	1.07	1.19	
December	6,485	1,155	2,384	1.16	1.34	
The year	39,120	325	2,507	1.22	16.63	

Monthly discharge of James River at Buchanan, Va., for 1895–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1899						
January	21,300	1,530	3,850	1.87	2.16	
February	21,100	1,400	7,291	3.54	3.69	
March	66,290	8,015	10,130	4.92	5.67	
April	6,132	1,965	3,034	1.47	1.64	
May	10,700	1,400	3,295	1.60	1.84	
June	2,640	655	1,181	.574	.640	
July	697	325	434	.211	.243	
August	935	325	402	.195	.225	
September	2,290	325	591	.287	.320	
October	380	275	316	.154	.178	
November	655	325	395	.192	.214	
December	2,207	325	630	.306	.353	
The year	66,290	275	2,629	1.28	17.17	
1900						
January	17,570	440	2,406	1.17	1.35	
February	17,200	655	4,343	2.11	2.20	
March	21,510	1,965	6,014	2.92	3.37	
April	6,132	1,155	2,682	1.30	1.45	
May	4,025	615	1,244	.604	.696	
June	9,850	835	2,260	1.10	1.23	
July	1,815	440	787	.382	.440	
August	740	275	410	.199	.229	
September	1,890	275	614	.298	.333	
October	22,120	505	1,667	.810	.934	
November	57,500	655	4,522	2.20	2.46	
December	17,570	1,155	3,056	1.48	1.71	
The year	57,500	275	2,500	1.21	16.40	
1901						
January	19,700	835	2,860	1.39	1.60	
February	1,890	835	1,307	.635	.661	
March	16,470	835	3,875	1.88	2.17	
April	29,770	2,825	9,179	4.46	4.98	
May	36,600	1,670	6,346	3.08	3.55	
June	27,040	1,965	5,807	2.82	3.15	
July	5,900	935	2,617	1.27	1.46	
August	19,300	835	4,830	2.35	2.71	
September	9,030	740	1,696	.824	.919	
October	1,600	575	789	.383	.442	
November	935	440	550	.267	.298	
December	67,450	575	8,597	4.18	4.82	
The year	67,450	440	4,038	1.96	26.76	
1902						
January	14,420	1,275	3,735	1.81	2.09	
February	45,690	1,530	7,212	3.50	3.64	
March	66,290	2,460	9,685	4.71	5.43	
April	7,210	1,530	3,714	1.80	2.01	
May	1,400	935	1,178	.572	.660	
June	1,530	740	961	.467	.521	
July	1,600	505	683	.332	.383	
August	787	440	548	.266	.307	
September	655	380	425	.207	.231	
October	987	440	615	.299	.345	
November	4,130	440	974	.473	.528	
December	8,362	1,400	3,426	1.66	1.91	
The year	66,290	380	2,762	1.46	18.06	

Monthly discharge of James River at Buchanan, Va., for 1895–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1903						
January	23,370	1,155	4,488	2.18	2.51	
February	42,760	3,310	7,667	3.73	3.88	
March	44,340	2,640	8,442	4.10	4.73	
April	16,830	2,825	5,520	2.68	2.99	
May	4,180	1,040	1,767	.859	.990	
June	10,410	985	3,322	1.61	1.80	
July	7,210	740	2,019	.981	1.13	
August	2,045	575	958	.466	.537	
September	12,210	575	1,759	.855	.954	
October	2,460	505	715	.347	.400	
November	575	440	498	.242	.270	
December	697	472	570	.277	.319	
The year	44,340	440	3,144	1.53	20.51	
1904						
January	5,785	505	1,186	.576	.664	
February	7,587	749	1,994	.969	1.04	
March	14,390	1,600	3,923	1.91	2.20	
April	13,720	1,074	3,032	1.47	1.64	
May	21,100	1,742	3,904	1.90	2.19	
June	15,900	925	3,232	1.57	1.75	
July	1,670	440	742	.361	.416	
August	1,086	392	627	.305	.352	
September	453	352	391	.190	.212	
October	353	325	336	.163	.188	
November	472	336	382	.186	.208	
December	855	380	473	.230	.265	
The year	21,100	325	1,685	.819	11.12	
1905						
January	5,352	583	1,154	.561	.647	
February	3,132	428	1,012	.492	.512	
March	25,370	2,109	5,488	2.67	3.08	
April	3,857	835	1,619	.787	.878	
May	17,380	723	3,898	1.89	2.18	
June	8,048	599	1,720	.836	.933	
July	42,860	1,167	5,393	2.62	3.02	
August	1,572	607	1,006	.489	.564	
September	2,207	369	671	.326	.364	
October	655	352	475	.231	.266	
November	505	440	444	.216	.241	
December	9,378	472	2,641	1.28	1.48	
The year	42,860	352	2,127	1.03	14.16	
1906						
January	18,000	1,860	4,750	2.31	2.66	A.
February	3,270	740	1,300	.631	.66	A.
March	12,800	698	4,250	2.06	2.38	A.
April	8,070	1,580	3,390	1.65	1.84	A.
May	2,210	706	1,310	.636	.73	A.
June	4,560	655	1,180	.573	.64	A.
July	3,450	519	861	.418	.48	B.
August	4,240	655	2,260	1.10	1.27	A.
September	3,610	835	1,520	.738	.82	A.
October	47,000	1,400	7,320	3.55	4.09	A.
November	11,300	1,040	2,460	1.19	1.33	A.
December	11,000	935	2,550	1.24	1.43	A.
The year	47,000	519	2,760	1.34	18.33	

Monthly discharge of James River at Buchanan, Va., for 1895–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1907						
January	11,600	1,890	4,600	2.23	2.57	A.
February	3,600	1,890	2,520	1.22	1.27	A.
March	9,950	2,040	5,040	2.45	2.82	A.
April	15,800	2,680	5,700	2.77	3.09	A.
May	6,870	1,340	2,780	1.35	1.56	A.
June	51,400	1,340	7,180	3.49	3.89	A.
July	2,040	825	1,220	.592	.68	A.
August	1,890	740	933	.453	.52	A.
September	14,400	585	2,140	1.04	1.16	A.
October	1,470	740	914	.444	.51	A.
November	12,200	740	2,990	1.45	1.62	A.
December	28,400	1,340	5,420	2.63	3.03	A.
The year	51,400	585	3,450	1.68	22.72	
1908						
January	53,000	3,040	6,670	3.24	3.74	B.
February	62,000	1,880	6,830	3.32	3.58	B.
March	15,100	3,040	5,860	2.84	3.27	A.
April	18,300	2,500	4,840	2.35	2.62	A.
May	21,500	2,680	5,300	2.57	2.96	A.
June	6,480	1,030	2,390	1.16	1.29	A.
July	3,620	745	1,290	.626	.72	B.
August	3,820	585	1,160	.563	.65	B.
September	2,500	515	814	.395	.44	B.
October	8,760	515	1,580	.767	.88	B.
November	3,240	660	1,540	.748	.83	B.
December	9,030	930	2,280	1.11	1.28	A.
The year	62,000	515	3,380	1.64	22.26	
1909						
January	15,100	2,340	5,630	2.73	3.15	A.
February	16,800	1,740	4,830	2.34	2.44	A.
March	11,600	2,180	4,210	2.04	2.35	A.
April	33,600	1,480	5,150	2.50	2.79	B.
May	20,300	1,880	5,690	2.76	3.18	B.
June	5,100	1,140	2,550	1.24	1.38	A.
July	2,860	660	1,230	.597	.69	A.
August	1,240	515	729	.354	.41	A.
September	4,660	515	814	.395	.44	A.
October	2,680	450	772	.375	.43	B.
November	660	585	592	.287	.32	A.
December	5,100	....	1,070	.519	.60	B.
The year	33,600	....	2,770	1.34	18.18	
1910						
January	15,400	585	3,000	1.46	1.68	A.
February	12,800	1,240	3,310	1.61	1.68	A.
March	10,400	1,030	2,680	1.30	1.50	A.
April	5,780	1,030	2,370	1.15	1.28	A.
May	2,340	1,030	1,420	.689	.79	A.
June	47,000	930	8,240	4.00	4.46	B.
July	14,400	930	2,620	1.27	1.46	A.
August	930	515	658	.319	.37	A.
September	1,480	450	592	.287	.32	A.
October	835	450	561	.272	.31	A.
November	515	450	463	.225	.25	A.
December	2,500	450	692	.336	.39	A.
The year	47,000	450	2,200	1.07	14.49	

Monthly discharge of James River at Buchanan, Va., for 1895-1914—Continued.

Month	Discharge in second-feet: Maximum	Minimum	Mean	Per square mile	Run-off (depth in inches on drainage area)	Accuracy
1911						
January	24,400	1,240	4,910	2.38	2.74	A.
February	11,600	1,480	3,130	1.52	1.58	A.
March	10,100	1,360	4,390	2.13	2.46	A.
April	18,700	2,340	7,720	3.75	4.18	A.
May	2,340	835	1,300	.631	.73	A.
June	1,740	585	880	.427	.48	A.
July	1,140	385	654	.317	.37	A.
August	4,880	385	707	.343	.40	A.
September	4,660	515	1,070	.519	.58	A.
October	10,100	515	2,320	1.13	1.30	A.
November	4,030	745	1,880	.913	1.02	A.
December	8,760	835	2,410	1.17	1.35	A.
The year	24,400	385	2,610	1.27	17.19	
1912						
January	6,960	1,360	2,640	1.28	1.48	A.
February	13,800	1,120	4,070	1.98	2.14	A.
March	50,300	2,340	9,780	4.75	5.48	B.
April	13,100	2,030	4,080	1.98	2.21	A.
May	23,600	1,480	5,700	2.77	3.19	B.
June	2,340	690	1,070	.519	.58	A.
July	2,680	600	1,110	.539	.62	A.
August	520	385	426	.207	.24	A.
September	2,030	325	555	.269	.30	A.
October	600	385	447	.217	.25	A.
November	5,780	450	1,030	.500	.56	A.
December	7,720	450	795	.368	.44	A.
The year	50,300	325	2,640	1.28	17.49	
1913						
January	6,480	1,160	3,060	1.49	1.72	B.
February	10,100	930	2,290	1.11	1.16	B.
March 1-26	28,800	1,530	6,280	3.05	2.95	B.
April 22-30	4,240	2,640	3,200	1.55	.52	B.
May	13,100	1,530	3,870	1.88	2.17	B.
June	6,720	1,400	2,740	1.33	1.48	B.
July	7,460	1,400	2,450	1.19	1.37	B.
August	2,640	1,280	1,690	.820	.94	B.
September	1,290	430	758	.368	.41	B.
October	5,780	515	1,520	.738	.85	B.
November	12,500	1,040	3,230	1.57	1.75	B.
December	8,230	1,280	2,760	1.34	1.54	B.
1914						
January	9,300	2,460	4,310	2.09	2.41	B.
February	16,100	2,640	7,040	3.42	3.56	B.
March	9,850	2,820	4,670	2.27	2.62	B.
April	13,100	3,620	5,450	2.65	2.96	B.
May	4,450	1,040	2,130	1.03	1.19	B.
June	930	515	695	.337	.38	B.
July	2,640	515	775	.376	.43	B.
August	1,400	430	543	.264	.30	A.
September	610	430	453	.220	.25	A.
October	5,100	430	897	.435	.50	A.
November	1,670	515	726	.352	.39	A.
December	16,500	3,020	5,580	2.71	3.12	B.
The year	16,500	430	2,750	1.33	18.11	

NOTE.—Estimates of discharge for the following periods are subject to considerable error owing to inaccuracy of gage: Jan. 24 to July 9, 1896; Oct. 15 to Dec. 31, 1897; Jan. 1 to Feb. 13, 1898; and Apr. 1 to July 6, 1899.

Discharge relation probably affected by ice during part of January, 1905, but no correction was made in discharge estimates; also probably affected by ice Dec. 23-31, 1909, and discharge for this period was estimated at about 28 per cent of the discharge at the Cartersville station.

JAMES RIVER AT HOLCOMB ROCK, VA.

Location.—At the works of the Virginia Electrolytic Co. at Holcomb Rock, Va.

Drainage area.—Not measured.

Records available.—Gage heights January 1, 1900, to December 31, 1914.

Gage.—Copper float inclosed in a perforated box in the tailrace of the plant; vertical rod, graduated to tenths of feet, is attached to float and extends up through power-house floor; gage read twice daily.

Discharge measurements.—None made.

Channel and control.—No information.

Extremes of stage.—Maximum stage observed; 26.8 feet at 8 A. M., March 28, 1913. Minimum stage recorded: —0.9 foot, September 14, 1913.

Winter flow.—No information.

Coöperation.—Gage-height records furnished by Virginia Electrolytic Co.

Daily gage height, in feet, of James River at Holcomb Rock, Va., for 1906–1914.

[G. L. Price, J. H. Webb, and R. D. Damson, observers.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	3.9	2.9	1.3	5.75	1.75	1.6	1.4	1.5	3.8	3.45	2.25	1.85
2	3.75	2.75	1.3	4.9	1.8	1.7	1.5	1.4	2.65	3.8	2.2	1.8
3	3.0	2.45	1.7	4.05	1.75	1.35	1.05	1.3	2.45	5.85	2.1	1.7
4	2.5	2.0	4.2	3.6	1.7	1.3	2.05	1.3	2.25	9.55	1.95	1.7
5	2.4	2.1	4.8	3.15	1.7	1.3	1.85	1.0	2.05	9.65	1.85	1.65
6	2.55	2.1	3.7	2.95	1.55	1.5	1.55	1.5	1.9	6.6	1.7	1.7
7	3.0	2.0	2.9	2.75	2.25	1.55	1.45	2.0	1.8	5.65	1.7	1.65
8	3.3	1.75	2.55	2.55	2.1	1.35	1.1	2.35	1.7	4.65	1.7	1.6
9	2.95	1.7	2.35	2.6	2.05	1.3	1.15	2.1	1.6	3.85	1.7	1.45
10	2.55	1.7	2.3	3.15	2.0	1.15	1.2	2.05	1.55	3.2	1.65	1.5
11	2.2	1.7	2.0	3.75	1.85	1.25	1.2	1.7	1.5	2.7	1.55	1.6
12	2.1	1.55	2.0	3.4	1.8	1.3	1.2	1.6	1.55	2.45	1.65	1.55
13	2.1	1.6	1.9	3.1	1.55	1.3	1.1	1.7	1.85	2.15	1.7	1.5
14	2.4	1.55	1.85	2.7	1.6	1.4	1.2	2.15	2.25	2.0	1.65	1.4
15	2.4	1.55	2.25	3.3	1.55	1.3	1.1	3.45	1.8	1.95	1.6	1.4
16	2.55	1.5	5.4	4.6	1.5	1.3	1.35	4.2	1.5	1.85	1.6	1.45
17	2.55	1.5	5.15	4.4	1.5	1.1	1.3	4.05	1.35	1.8	1.6	1.6
18	2.5	1.25	3.7	3.65	1.6	1.4	1.2	3.6	1.35	3.4	1.55	4.7
19	2.5	1.5	3.6	3.2	1.65	1.5	1.25	3.0	1.4	13.4	3.95	6.8
20	2.3	1.45	3.85	2.9	1.6	4.75	1.3	3.2	1.4	19.0	9.85	4.35
21	2.0	1.35	3.9	2.65	1.5	4.5	1.1	3.2	1.3	12.3	7.85	3.7
22	2.05	1.4	3.85	2.55	1.4	3.55	1.2	2.9	1.4	8.1	5.8	3.55
23	5.85	1.3	3.4	2.4	1.3	2.65	1.7	2.75	1.6	6.3	4.2	3.35
24	9.85	1.4	3.3	2.25	1.3	2.05	1.4	2.8	1.9	5.45	3.35	2.8
25	6.3	1.1	2.95	2.1	1.3	1.95	1.3	2.9	1.65	4.4	2.85	2.55
26	4.7	1.35	2.9	2.1	1.3	1.7	1.3	2.8	1.55	3.8	2.65	2.35
27	4.0	1.35	3.65	2.0	1.3	2.1	1.3	2.75	1.4	3.4	2.45	2.2
28	3.75	1.3	7.1	2.0	1.5	1.65	1.3	4.75	1.6	3.2	2.25	2.2
29	4.1	....	6.5	1.85	1.6	1.85	1.5	5.9	2.15	2.85	2.05	2.2
30	3.8	....	5.8	1.75	1.8	1.6	2.06	4.6	2.25	2.5	1.85	2.1
31	3.35	....	5.85	....	1.7	....	1.7	3.85	....	2.35	....	3.1
1907												
1	5.75	2.1	3.5	2.85	2.4	3.1	2.2	1.4	1.1	2.0	1.3	2.4
2	5.7	2.1	3.5	4.05	2.4	8.45	2.15	1.5	1.3	1.9	1.35	2.35
3	5.15	2.4	5.85	3.25	2.35	7.15	1.95	1.3	1.25	1.75	1.85	2.25
4	3.65	2.5	5.3	2.85	2.3	4.9	1.75	.95	1.25	1.65	3.05	2.1
5	3.35	2.55	4.1	2.7	2.15	4.05	1.95	1.35	1.35	1.6	2.4	2.0
6	2.95	2.5	3.6	2.95	2.35	3.75	1.75	1.3	1.95	1.35	1.95	1.9
7	2.85	2.15	3.3	7.0	4.1	3.35	1.65	1.3	1.75	1.6	2.0	1.85
8	2.7	2.1	3.15	6.85	4.95	3.05	1.85	1.3	1.05	1.6	1.75	1.5
9	2.6	2.1	3.0	9.95	4.1	5.45	1.7	1.3	1.3	1.5	1.7	1.95
10	2.5	1.9	3.3	10.15	3.95	5.0	1.7	1.4	1.2	1.5	1.65	5.2
11	2.5	2.55	3.7	6.9	3.95	3.9	1.7	1.35	1.4	1.7	2.9	8.9
12	2.5	2.95	4.8	5.55	3.45	4.35	1.7	1.5	2.25	1.65	3.35	6.5
13	2.45	2.6	4.65	4.6	2.9	6.0	1.75	1.5	2.5	1.35	2.55	5.2
14	2.5	2.4	6.2	4.0	2.65	16.15	1.55	1.5	1.85	1.45	2.3	4.35
15	3.1	2.4	5.7	3.6	2.5	11.1	1.65	1.4	1.4	1.4	2.1	4.6
16	3.95	2.4	5.2	3.25	2.65	6.95	1.6	1.35	1.5	1.4	1.95	4.55
17	6.0	2.2	4.1	2.95	2.45	5.15	1.6	1.3	1.35	1.4	1.65	4.1
18	6.55	2.3	3.7	2.8	2.25	4.05	1.6	1.1	1.3	1.4	2.05	3.55
19	0.8	2.25	3.45	2.75	1.9	3.45	1.7	1.2	1.5	1.4	2.85	3.25
20	6.5	2.2	3.8	2.6	1.95	3.2	2.0	1.2	1.3	1.05	3.0	3.05
21	4.85	2.15	4.75	2.55	1.9	2.75	1.75	1.2	1.3	1.4	3.0	2.7
22	4.0	2.1	4.25	2.55	1.8	2.4	1.7	1.45	1.15	1.35	3.15	2.5
23	3.3	2.0	3.55	2.55	1.8	2.85	1.6	1.4	9.65	1.25	3.3	7.05
24	2.85	1.7	3.05	3.35	1.7	3.25	1.4	1.4	10.35	1.2	7.1	11.65
25	2.55	1.85	2.8	4.2	1.75	3.1	1.4	2.2	5.25	1.2	8.2	8.55

Daily gage height, in feet, of James River at Holcomb Rock, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	2.45	2.1	2.6	3.7	1.55	3.25	1.45	1.8	3.35	1.2	5.95	6.1
27	2.3	2.5	2.45	3.35	1.7	3.1	1.4	1.55	2.5	1.0	4.5	4.85
28	2.2	2.7	2.35	2.85	1.55	2.6	1.15	1.55	2.35	1.35	3.7	4.2
29	2.1	....	2.25	2.75	1.55	2.45	1.4	1.4	1.35	1.35	3.15	3.7
30	2.0	....	2.15	2.55	1.5	2.3	1.5	1.4	2.15	1.3	2.85	4.15
31	2.0	....	2.05	....	1.55	....	1.4	1.3	....	1.3	....	5.5
1908												
1	4.9	2.6	3.05	9.0	2.8	3.0	1.7	1.75	1.7	1.6	3.65	1.75
2	4.5	2.7	3.6	9.15	3.2	2.5	1.7	1.4	1.65	1.6	3.1	1.65
3	3.95	2.75	5.3	7.7	2.9	2.2	1.8	1.6	1.6	1.35	2.5	1.7
4	3.5	2.35	6.3	6.05	2.8	2.55	1.7	1.45	1.55	1.3	2.3	1.65
5	3.45	2.45	5.25	4.9	2.8	5.05	2.4	1.4	1.5	1.4	2.15	1.6
6	3.35	2.25	6.9	4.3	2.75	5.2	2.4	1.35	4.0	1.3	2.05	1.65
7	4.85	2.45	8.9	3.8	3.45	3.9	2.55	1.5	2.55	1.3	2.05	1.8
8	5.3	2.4	7.8	3.45	9.4	3.25	2.45	1.5	2.1	1.25	1.75	2.0
9	4.35	2.35	6.55	3.15	6.65	3.0	2.2	1.45	1.9	1.3	1.85	2.3
10	3.65	2.4	5.65	3.0	5.0	2.9	1.95	1.85	1.8	1.4	1.7	2.2
11	3.15	2.4	4.85	2.95	4.45	2.75	1.8	2.15	1.7	1.15	1.75	2.2
12	11.35	2.15	4.3	2.85	3.9	3.15	1.5	1.95	1.6	1.9	1.7	2.45
13	18.25	3.45	3.95	2.95	3.4	3.05	1.8	1.7	1.4	1.6	1.7	3.55
14	10.0	7.8	3.65	2.75	3.05	2.65	1.6	1.7	1.5	1.45	1.7	3.3
15	7.3	13.95	3.4	2.7	2.75	2.7	1.65	1.65	1.45	1.4	1.65	2.75
16	5.8	17.5	3.25	2.7	2.65	3.8	1.45	1.15	1.5	1.4	1.85	2.55
17	5.1	9.25	3.15	2.8	2.5	3.05	1.5	1.55	1.5	1.2	1.7	2.35
18	4.35	6.75	3.4	2.95	2.5	2.75	1.45	1.5	1.5	1.3	1.8	2.2
19	3.95	5.45	4.05	2.8	2.75	2.45	1.3	1.4	1.5	1.0	2.6	2.2
20	3.55	4.9	5.45	2.85	4.1	2.25	1.45	1.4	1.1	1.2	3.2	2.05
21	3.35	4.25	4.9	2.75	5.5	2.05	1.55	1.4	1.6	1.25	3.05	2.0
22	3.15	3.8	4.3	2.6	6.2	2.25	1.5	1.3	1.4	1.05	2.75	2.0
23	3.1	3.45	4.2	2.45	5.85	2.0	1.6	1.35	1.3	1.2	2.55	1.95
24	3.15	3.25	4.25	2.4	6.1	2.0	1.8	1.45	1.25	3.95	2.35	1.6
25	3.05	3.1	4.25	2.85	4.8	2.1	1.85	1.7	1.3	5.75	2.2	2.05
26	2.8	3.3	3.9	2.35	3.75	1.9	1.8	5.4	1.3	3.3	2.1	2.45
27	3.1	3.85	3.5	3.45	3.25	1.9	1.65	4.5	1.15	2.5	1.95	3.25
28	3.8	3.7	3.25	3.0	3.6	1.7	3.05	3.0	1.6	2.2	1.85	3.0
29	3.3	3.25	3.05	2.65	4.2	1.75	2.9	2.4	1.8	3.6	1.75	3.2
30	2.9	....	3.05	2.6	4.35	1.75	2.2	2.0	1.6	6.95	1.9	3.9
31	2.7	....	3.5	....	3.4	....	1.95	1.9	....	5.25	....	6.4
1909												
1	7.0	2.85	3.9	3.3	3.25	4.25	2.55	1.2	1.0	1.0	1.0	1.0
2	5.6	2.5	3.4	3.1	5.1	4.55	3.2	1.65	1.05	.85	1.05	1.0
3	4.2	2.5	3.4	2.9	4.7	3.0	2.55	1.6	.8	.7	1.0	1.0
4	3.7	2.45	3.6	2.7	3.9	4.95	2.2	1.6	.9	.95	1.0	1.0
5	4.65	2.4	4.1	2.8	3.5	4.85	2.0	1.4	.75	.9	.9	.75
6	8.65	2.35	3.5	2.6	3.15	4.3	2.0	1.6	.85	.85	1.0	1.05
7	7.05	2.2	3.85	2.45	2.85	3.65	2.5	1.55	.95	.8	.8	1.0
8	5.35	2.3	3.75	2.35	2.65	3.5	2.75	1.6	1.05	.8	1.1	1.0
9	4.3	2.3	4.2	2.3	2.6	3.5	2.3	1.55	1.35	.75	1.0	1.0
10	3.65	5.45	4.2	2.2	3.0	3.65	2.05	1.45	1.1	.85	1.0	1.0
11	3.25	9.65	4.2	2.05	5.9	3.4	1.8	1.4	1.1	1.05	1.05	1.25
12	3.1	7.0	3.75	2.05	4.7	3.25	1.95	1.25	.95	3.15	1.0	.85
13	2.85	5.0	3.55	2.1	3.75	2.95	1.8	1.1	1.0	2.35	1.0	1.45
14	2.7	4.35	3.4	10.75	3.5	3.1	1.5	1.05	1.0	1.75	.9	5.15
15	2.7	4.05	3.25	12.75	2.95	2.75	1.5	1.3	.95	1.55	1.1	4.75
16	3.25	3.8	3.05	7.5	2.7	2.55	1.5	1.55	1.0	1.35	1.1	3.15
17	5.7	4.0	2.9	5.6	2.7	2.6	1.6	1.65	1.0	1.1	1.0	2.4
18	5.55	4.45	2.75	4.5	2.4	3.1	1.25	1.75	2.8	1.2	1.0	2.2
19	5.0	3.8	2.65	4.05	2.25	2.45	1.65	1.6	1.65	1.15	1.0	1.85
20	4.55	3.9	2.55	3.55	2.15	2.25	1.45	1.5	1.75	1.2	1.0	1.85

Daily gage height, in feet, of James River at Holcomb Rock, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	4.7	4.0	2.35	3.35	4.55	2.25	1.4	1.3	1.45	1.15	.85	1.6
22	5.25	4.1	2.6	3.25	10.4	2.15	1.35	.9	1.25	.9	1.0	1.45
23	5.5	4.2	2.65	3.25	7.7	2.0	1.35	1.1	1.2	.9	1.0	1.5
24	6.1	5.0	3.1	4.15	5.6	2.05	1.4	1.15	1.15	.8	1.0	1.25
25	6.05	6.05	4.55	4.5	4.4	2.0	1.1	1.05	1.0	.95	1.0	1.3
26	5.15	6.1	7.5	3.95	5.95	2.0	1.4	1.25	.85	1.1	.95	1.35
27	4.3	5.15	5.8	3.5	7.95	2.0	1.5	.9	1.2	1.15	.95	1.35
28	3.7	4.35	4.7	3.15	6.45	2.15	1.4	1.0	1.0	1.2	.85	1.4
29	3.3	....	4.25	2.95	5.0	2.3	1.3	.75	1.05	1.15	1.0	1.4
30	3.2	....	4.1	2.9	3.9	2.5	1.3	1.05	1.0	.95	1.0	1.15
31	3.0	....	3.7	....	3.55	....	1.45	1.05	....	.9	....	1.0
1910												
1	1.05	2.05	4.8	1.7	2.65	1.55	2.15	1.45	1.3	1.15	1.15	1.05
2	1.2	1.9	7.2	1.6	2.5	1.5	2.1	1.4	1.4	.8	.9	1.1
3	1.4	1.95	5.85	1.45	2.3	1.5	2.0	1.35	1.35	1.05	.9	.95
4	1.45	2.25	4.9	1.75	2.15	1.5	1.9	1.5	1.25	.85	1.0	.65
5	1.75	2.5	4.2	1.8	2.05	1.15	2.15	1.4	1.4	.95	1.1	1.1
6	1.95	2.5	3.55	2.0	1.85	1.55	2.0	1.3	1.7	.9	.8	1.3
7	2.85	2.35	3.35	1.9	1.8	1.6	2.55	1.15	1.35	1.0	1.0	1.0
8	5.45	2.1	3.05	1.8	1.65	1.75	2.4	1.4	1.3	1.3	1.0	1.2
9	8.7	2.2	2.85	1.8	2.05	1.7	2.4	1.3	1.4	1.45	.95	1.15
10	2.9	2.1	2.65	1.5	1.85	1.6	2.4	1.35	1.4	1.5	.95	1.05
11	2.3	2.0	2.6	1.6	1.8	2.95	2.45	1.3	.8	1.5	1.0	.8
12	2.25	2.0	2.5	1.6	1.8	7.35	2.2	1.25	1.1	1.5	1.0	1.25
13	2.15	1.6	2.35	1.85	1.8	10.35	2.1	1.3	1.05	.85	.25	1.1
14	2.0	1.85	2.25	2.35	1.8	15.6	2.25	.7	1.0	1.05	1.0	.95
15	1.9	1.9	2.2	2.4	1.65	10.2	2.9	1.35	1.1	.95	.95	1.0
16	1.75	1.95	2.2	2.3	1.7	12.65	2.9	1.3	1.2	.8	1.0	.9
17	1.8	2.7	2.1	3.65	1.7	14.5	3.75	.9	1.2	.95	1.0	.9
18	1.7	9.0	2.1	5.75	1.7	9.8	4.35	1.05	.7	.75	.9	.6
19	1.85	8.95	2.1	5.45	1.7	6.8	7.7	1.35	1.0	1.1	.8	.8
20	2.1	5.3	2.0	4.45	1.7	5.85	4.9	1.2	1.1	1.05	.65	.75
21	4.05	4.35	2.0	3.8	1.7	4.65	3.55	.85	.85	1.15	1.0	1.05
22	8.65	4.2	1.9	3.25	1.4	4.1	2.95	1.3	.95	1.35	.9	.8
23	6.45	4.45	1.9	2.85	2.95	3.75	2.65	1.3	.85	1.05	.95	1.0
24	4.35	4.25	1.7	2.65	1.7	3.7	2.0	1.5	.85	1.45	.95	1.15
25	3.4	3.55	1.75	2.55	1.85	3.9	2.15	1.15	.8	1.4	.85	1.05
26	2.95	3.2	1.75	2.7	1.9	2.85	1.95	.55	1.05	1.35	1.05	1.25
27	2.65	2.8	1.55	2.8	1.95	2.75	1.9	1.15	.95	1.1	.5	1.8
28	2.55	2.95	1.75	2.9	1.8	2.7	1.8	1.0	1.15	1.1	1.15	1.15
29	2.45	....	1.7	2.9	1.6	2.4	1.8	1.35	.95	1.15	1.2	1.85
30	2.3	....	1.7	2.9	1.7	2.4	1.7	1.3	.95	.85	1.15	1.6
31	2.3	....	1.65	....	1.55	....	1.35	1.3	....	.85	....	2.75
1911												
1	5.1	6.3	1.9	4.25	2.4	1.45	1.15	0.7	4.85	0.95	1.45	1.8
2	6.2	4.8	1.5	3.65	2.45	1.4	.9	.8	3.45	.9	1.4	1.7
3	8.5	4.2	1.9	3.5	2.45	1.2	.85	.75	2.35	1.0	1.4	1.65
4	11.0	3.7	1.9	3.9	2.4	1.2	.05	1.1	1.9	1.1	1.25	1.7
5	7.5	3.1	1.6	7.55	2.2	1.25	1.15	1.05	1.65	1.25	1.3	1.65
6	4.8	3.0	2.0	9.55	2.2	1.5	1.75	1.15	1.4	.9	1.8	1.6
7	3.6	2.8	4.0	7.65	1.95	1.7	1.2	1.0	1.3	.95	3.65	1.5
8	2.8	2.6	3.9	6.4	2.05	1.8	1.5	1.0	1.2	1.05	5.4	1.4
9	2.6	2.8	3.2	6.3	1.9	2.45	1.4	.9	1.2	1.0	3.65	1.4
10	2.2	4.8	8.4	6.1	2.0	1.8	1.35	1.05	1.1	1.1	2.95	1.4
11	2.1	4.4	6.8	5.1	2.0	1.25	1.2	.9	1.25	1.15	2.65	1.4
12	2.1	3.5	5.8	4.55	1.8	1.5	1.4	.85	1.25	1.2	2.45	1.3
13	2.0	3.2	4.6	4.0	1.75	1.4	1.4	.65	1.3	1.25	2.85	1.3
14	2.2	3.0	4.2	3.9	1.3	1.3	1.4	1.25	1.5	1.0	2.4	1.3
15	2.3	2.8	4.4	5.1	1.75	1.25	1.7	1.35	1.45	1.3	2.4	1.4

Daily gage height, in feet, of James River at Holcomb Rock, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
16	2.4	2.6	4.1	6.05	1.5	1.15	1.4	1.4	1.8	1.25	2.3	2.1
17	2.2	2.4	3.6	5.55	1.5	1.15	1.25	1.3	1.15	1.7	2.8	2.4
18	2.2	2.3	3.2	4.65	1.5	1.0	1.15	1.15	1.2	6.85	2.1	2.4
19	2.0	2.0	2.9	4.15	1.5	1.2	1.1	1.1	1.35	8.35	2.1	2.25
20	1.9	2.4	3.2	4.0	1.35	1.25	.95	.85	1.3	4.25	2.55	2.1
21	1.9	2.4	3.9	4.4	1.2	1.2	.65	.8	1.3	3.05	2.6	1.8
22	1.9	2.4	3.6	4.25	1.4	1.2	1.0	1.0	1.2	2.55	2.5	1.8
23	3.6	2.3	3.2	3.7	1.05	1.2	.95	.8	1.2	2.45	2.1	4.15
24	4.6	2.2	3.0	3.65	1.3	1.2	.8	.75	.85	2.3	2.1	6.3
25	3.6	2.2	2.6	3.25	1.3	1.2	.7	.85	1.1	2.3	1.9	5.55
26	3.1	1.9	2.4	2.9	1.25	1.3	.7	.75	1.05	2.15	1.9	5.15
27	2.7	2.0	3.0	2.75	1.35	1.2	.8	1.0	.9	2.05	1.9	5.15
28	2.8	2.0	4.0	2.55	1.3	1.2	.7	.95	.7	1.9	1.9	5.35
29	2.7	....	3.8	3.25	1.4	1.15	.7	1.0	1.1	1.7	1.8	4.65
30	5.4	....	3.9	2.8	1.45	1.1	.7	1.65	.9	1.7	1.8	4.0
31	10.5	....	4.5	....	1.2	....	.95	4.4	....	1.7	....	3.5
1912												
1	4.7	4.4	4.5	7.05	2.65	2.05	2.25	1.85	0.85	1.35	.85	1.05
2	5.0	3.5	3.9	6.55	2.6	1.9	2.15	1.3	.85	1.3	1.0	1.3
3	4.15	3.1	3.4	8.2	2.5	2.05	2.1	1.3	.9	1.0	.85	1.2
4	3.6	2.35	3.2	7.0	2.5	2.0	1.8	.85	.85	1.2	.9	1.15
5	2.35	2.4	3.0	5.65	2.1	1.9	1.85	1.05	.8	1.1	.8	1.25
6	2.6	2.7	2.75	4.85	2.35	1.8	1.95	1.0	.85	.8	.80	1.4
7	2.65	2.45	2.65	4.5	2.3	1.8	1.95	1.0	.75	1.1	1.9	1.35
8	2.65	2.15	2.55	4.3	2.8	1.65	1.8	.85	.9	.95	4.45	1.15
9	2.35	2.1	3.15	3.8	2.4	1.45	1.7	1.0	1.05	.9	3.75	1.55
10	2.15	2.1	4.1	3.55	2.7	1.45	1.5	1.0	1.0	.95	3.05	1.5
11	2.25	1.7	4.1	3.35	2.4	1.4	1.5	.9	1.0	1.0	2.35	1.4
12	2.2	1.85	4.05	3.2	12.85	1.4	1.5	1.0	.95	.95	2.05	1.25
13	1.95	1.8	7.25	2.95	12.05	1.45	1.85	.80	.95	.65	1.9	1.35
14	1.55	1.85	7.75	2.75	8.0	1.4	1.4	1.15	.55	1.0	1.8	1.2
15	1.05	1.75	8.95	2.8	6.1	1.3	2.3	1.1	.85	.75	1.7	.85
16	2.15	1.7	14.95	2.75	7.1	1.2	1.65	.95	.8	.85	1.7	1.25
17	1.85	1.65	10.5	3.45	11.1	1.35	1.55	.8	.0	1.1	1.25	1.3
18	1.8	1.6	7.3	4.0	7.95	1.45	1.45	.8	.9	.9	1.5	1.15
19	1.9	1.7	5.95	3.6	5.95	1.4	1.6	.7	1.5	1.05	1.25	1.3
20	2.6	1.85	5.2	3.55	4.95	1.5	1.6	.95	1.4	.65	1.15	1.1
21	3.3	2.25	4.75	2.9	4.2	1.5	1.4	1.0	1.0	.85	1.25	1.25
22	3.2	7.55	4.65	2.9	3.7	1.4	1.4	1.0	.75	.85	1.3	1.0
23	2.95	8.65	4.4	2.8	3.35	1.35	1.4	.75	1.75	1.0	1.25	1.15
24	2.75	5.4	4.9	2.7	3.0	1.55	1.35	.9	3.9	1.05	1.05	1.15
25	2.6	4.6	9.15	2.55	2.8	1.45	1.4	.85	2.85	1.0	1.35	1.1
26	2.6	4.3	9.85	2.85	2.5	1.8	1.35	.85	2.45	.95	1.3	1.2
27	2.5	7.5	7.1	2.4	2.55	1.8	1.4	1.0	2.1	.8	1.2	1.15
28	2.4	7.65	5.8	2.3	2.45	2.5	1.4	.8	1.8	.9	1.2	1.15
29	2.4	5.65	11.8	2.85	2.35	2.4	1.35	.85	1.85	.95	1.15	1.1
30	2.85	....	15.45	2.8	2.3	2.0	1.4	.85	1.6	1.0	1.0	1.25
31	4.95	....	9.1	....	2.15	....	1.15	.9	....	.8	....	1.15
1913												
1	5.95	2.9	3.5	3.55	1.4	3.0	1.15	0.95	0.5	−0.15	0.7	1.2
2	3.8	2.8	2.45	3.15	1.15	2.6	1.1	1.5	.1	.1	.6	2.25
3	3.45	3.0	2.05	2.6	1.05	2.45	1.1	1.2	.15	− .25	.6	3.1
4	3.7	3.1	1.6	2.25	1.3	2.4	4.9	1.2	.25	.0	.35	2.45
5	3.8	4.4	1.35	2.2	1.25	2.4	2.25	1.0	.2	.2	.35	2.0
6	3.2	3.8	1.25	1.95	1.3	2.05	1.7	1.05	.15	− .2	.35	1.45
7	2.8	3.35	1.15	1.75	1.25	1.85	1.5	1.25	− .25	.05	.25	1.5
8	3.6	2.85	.9	1.55	1.35	2.25	1.25	1.25	.05	− .35	.3	1.65
9	4.3	2.4	.65	1.5	1.4	2.15	1.1	1.2	− .05	− .4	5.7	1.85
10	4.05	2.45	.85	1.3	1.4	1.9	1.0	.6	− .3	.25	8.05	1.7

Daily gage height, in feet, of James River at Holcomb Rock, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	3.4	2.85	1.2	1.35	1.1	1.55	1.5	.9	— .2	.85	4.3	1.5
12	2.85	.95	2.35	5.85	1.2	1.5	2.1	1.4	— .1	.4	3.0	1.35
13	2.75	.9	2.05	8.2	1.2	1.4	1.3	1.65	— .2	.6	2.8	1.25
14	2.5	.8	9.45	8.9	1.2	1.4	1.1	2.15	— .5	.6	2.05	1.05
15	2.5	.65	12.3	8.55	1.2	1.2	1.1	1.45	— .35	.4	2.65	1.05
16	2.5	.5	11.4	9.3	1.2	1.2	.85	1.3	— .35	.45	2.65	1.0
17	2.25	.7	7.35	6.9	1.3	1.15	.35	1.0	— .1	.15	3.2	.9
18	2.1	.6	4.9	4.95	1.2	1.2	.65	1.05	— .1	.15	3.35	.9
19	2.0	.6	3.55	3.9	1.2	1.05	.95	.9	.0	.1	2.7	.85
20	2.05	.5	2.95	3.25	1.2	1.2	1.9	1.25	— .3	.8	2.25	.8
21	2.0	.6	2.5	2.75	1.2	1.55	1.85	1.3	.75	1.1	1.85	.45
22	1.85	.6	2.15	2.35	1.6	.85	1.2	1.1	.6	1.55	1.5	.7
23	1.8	.35	1.85	2.2	4.8	1.35	1.25	1.0	.45	1.35	1.25	.6
24	1.75	.65	1.6	2.1	9.3	1.2	1.25	.8	.45	1.15	1.25	.75
25	1.8	.55	1.4	1.8	6.7	1.2	1.05	1.0	.25	1.95	1.0	.8
26	1.7	.55	1.65	1.7	4.35	1.1	1.3	1.0	.2	2.65	1.0	3.35
27	2.15	.75	7.75	1.7	....	1.65	.65	.95	.1	2.35	.95	4.9
28	3.9	3.05	25.8	1.65	6.1	1.4	1.15	.8	.1	1.85	.9	3.35
29	4.4	....	8.05	1.6	6.45	1.3	1.1	.8	— .05	1.45	.85	2.65
30	3.55	....	5.7	1.55	4.45	1.2	1.05	.65	— .15	1.25	.9	2.15
31	3.05	....	4.2	....	3.45	....	.9	.55	....	.9	....	1.85
1914												
1	1.75	9.85	2.7	2.5	2.05	0.3	−0.45	−0.35	−0.3	−0.6	−0.4	2.7
2	1.55	7.0	2.7	2.5	1.85	.2	— .4	— .4	— .45	— .7	— .4	3.05
3	2.3	4.7	2.4	2.75	1.55	.35	.1	— .5	— .35	— .65	— .5	2.25
4	3.7	3.7	2.2	2.75	1.55	.2	— .45	— .4	— .3	— .65	— .35	1.7
5	2.85	3.2	2.15	2.5	1.5	.1	.15	— .45	— .45	— .4	— .4	8.65
6	2.35	3.25	2.1	2.3	1.65	.2	.65	— .4	— .6	— .3	— .4	8.65
7	2.25	5.6	2.1	2.05	1.8	.0	.35	— .4	— .6	— .3	— .55	5.3
8	2.2	7.6	1.9	1.9	1.7	.15	.1	— .4	— .6	— .35	— .3	3.45
9	2.35	5.75	2.0	1.9	1.6	.1	.45	— .4	— .55	— .35	— .4	2.7
10	3.7	4.35	1.75	1.9	1.25	.0	— .2	— .35	— .5	— .1	— .5	2.2
11	5.05	3.6	1.8	1.8	1.3	.05	.3	— .4	— .45	— .3	— .55	2.05
12	3.9	2.9	2.1	1.5	1.2	.05	.0	.0	— .35	— .3	— .4	1.85
13	2.9	2.55	2.8	1.6	1.1	.05	.8	— .15	— .45	— .45	— .55	1.65
14	2.25	2.05	2.9	1.5	1.0	.0	1.15	— .35	— .35	— .2	— .4	1.6
15	2.1	2.0	2.65	2.35	.9	.0	1.1	— .3	— .5	— .25	.55	1.35
16	2.0	2.05	3.0	3.25	.85	.0	.9	— .4	— .5	1.65	1.2	1.0
17	1.8	1.75	4.05	4.3	.6	— .2	.95	— .4	— .6	2.4	.9	.6
18	1.45	1.7	5.65	3.7	.8	— .1	.5	— .4	— .5	1.1	.55	.75
19	1.45	3.15	6.25	2.0	.75	— .35	.25	— .5	— .6	.55	.4	.8
20	1.4	7.5	4.75	2.7	.6	— .1	.05	— .6	— .6	.25	.2	1.35
21	1.45	7.2	3.95	3.05	.5	— .4	— .15	— .6	— .5	.1	.1	2.9
22	4.05	5.25	3.3	3.35	.4	— .25	— .2	— .6	— .6	.1	.0	4.4
23	3.5	4.85	2.95	2.85	.45	— .25	— .2	— .6	— .5	— .05	— .1	4.4
24	2.75	4.7	2.8	2.4	.2	— .3	— .2	— .5	— .6	— .1	— .05	3.05
25	3.35	3.8	2.5	2.45	.45	.0	— .4	— .5	— .5	— .2	— .15	2.4
26	6.1	3.8	2.4	1.9	.3	— .2	— .35	.0	— .6	— .1	— .15	2.0
27	4.25	3.4	2.5	4.35	.35	— .1	— .4	.05	— .6	— .25	— .2	1.5
28	3.3	2.6	3.2	3.1	.2	— .15	— .2	— .1	— .6	— .3	— .3	1.8
29	2.75	....	2.9	2.45	.25	.2	— .35	.05	— .6	— .3	— .3	1.25
30	2.35	....	2.8	2.1	.45	— .1	— .4	.0	— .6	— .3	— .1	2.25
31	3.8	....	2.5	....	.3	....	— .4	.05	....	— .3	....	4.6

JAMES RIVER AT CARTERSVILLE, VA.

Location.—At highway bridge between Pemberton and Cartersville, about 50 miles above Richmond. Willis River enters from the south about one mile above station, and Rivanna River from the north about 7 miles above.

Drainage area.—6,230 square miles.

Records available.—January 1, 1899, to December 31, 1914.

Gage.—Chain on downstream side and near Cartersville end of bridge. Wire gage used previous to July 24, 1903.

Discharge measurements.—Made from bridge.

Channel and control.—Both banks high; left bank overflows at a stage of about 20 feet. Bed of stream composed of rocks and sand; changes somewhat during floods.

Extremes of discharge.—Maximum stage observed: 26.7 feet at 6 p. m., December 30, 1901; discharge approximately 106,000 second-feet. Minimum stage observed: 0.5 foot, October 3, 1914; discharge 800 second-feet. A discharge of 603 second-feet (gage height, 0.42 foot) was measured September 8, 1897, but gage height of this measurement is probably subject to error.

Winter flow.—Ice forms only during severe winters, but discharge relation is seldom affected thereby.

Accuracy.—Records good except when changes in discharge relation, caused by shifting channel, have not been well determined by discharge measurements. Estimates at extremely high stages may be subject to considerable error, as discharge above point of overflow has not been accurately determined.

Discharge measurements of James River at Cartersville, Va., in 1906–1915.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1906				1911			
June 7	Robert Follansbee	2.22	3,400	July 30	Mathers and Dean	.65	1,020
1907				1912			
July 27	R. G. Knight	1.76	3,220	Mar. 18	E. A. Porter	12.8	35,100
1908				Nov. 20	Jackson and Batchelder	1.84	3,010
Apr. 28	Follansbee and Barrows	3.63	6,420	1914			
1909				Oct. 1	Mathers and Morgan	.62	1,050
July 21	G. C. Stevens	1.91	2,700	1915			
Sept. 9	Stevens and Thomas	1.09	1,470	June 26	H. J. Dean	1.61	2,630
1910							
Sept. 7	G. C. Stevens	1.62	2,690				

Daily gage height, in feet, of James River at Cartersville, Va., for 1906–1914.

[B. W. Palmore, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	4.98	5.37	2.22	8.62	2.9	2.6	3.0	2.98	6.03	4.88	3.95	3.1
2	4.38	4.8	2.4	8.2	2.88	4.85	2.15	3.75	5.38	3.50	3.65	2.95
3	3.85	4.2	2.52	6.95	2.8	3.62	1.9	3.6	4.55	5.15	3.45	2.8
4	17.0	3.38	10.1	6.05	2.8	2.59	1.85	2.78	3.97	12.4	3.22	2.7
5	12.2	3.6	8.25	5.32	2.7	2.1	2.5	2.55	3.52	15.2	3.1	2.7
6	11.2	3.5	7.05	4.9	2.78	2.05	2.38	2.2	3.15	11.9	3.0	2.62
7	7.9	3.3	5.85	4.6	2.75	2.08	2.42	1.7	2.92	9.4	2.9	2.5
8	6.15	3.15	4.9	4.25	3.8	2.05	2.15	2.92	2.7	7.2	2.8	2.48
9	5.35	3.08	4.38	4.15	3.3	2.08	1.85	2.98	2.5	6.65	2.72	2.45
10	4.7	3.45	3.95	5.45	2.9	1.97	1.6	4.0	2.4	5.52	2.65	2.35
11	4.1	3.0	3.5	5.02	2.9	1.8	1.6	3.72	2.05	4.82	2.75	2.35
12	3.85	2.82	3.3	5.2	2.72	1.7	1.6	3.65	2.2	4.12	2.85	2.5
13	3.8	2.65	3.15	5.15	2.6	1.6	1.68	4.82	2.5	3.62	2.85	2.38
14	3.9	2.8	3.02	4.7	2.55	1.65	1.55	3.72	3.15	3.25	2.68	2.3
15	4.12	2.65	3.3	10.0	2.25	1.85	1.42	2.95	2.55	3.12	2.55	2.25
16	4.1	2.5	8.65	9.4	2.35	1.75	1.3	4.32	2.4	2.9	2.65	2.2
17	4.0	2.4	6.45	7.25	2.28	2.0	1.6	5.58	2.25	2.82	2.58	2.2
18	3.95	2.32	6.95	6.82	2.2	2.4	1.7	9.32	2.08	3.1	2.48	3.8
19	3.9	2.38	5.98	5.9	2.15	1.88	1.6	6.75	2.15	7.8	8.9	8.75
20	3.7	2.1	8.7	5.15	2.12	1.98	1.58	5.32	2.38	21.8	9.95	8.2
21	3.55	2.3	6.95	4.75	2.2	5.2	2.72	5.65	2.11	23.3	10.8	7.48
22	3.82	2.38	6.58	4.47	2.0	7.05	2.3	4.82	2.02	18.7	10.2	6.0
23	3.28	2.45	5.62	4.15	2.8	6.85	2.88	6.55	2.0	12.2	7.8	5.25
24	3.95	2.3	5.0	3.95	1.9	4.47	3.3	4.6	2.2	9.55	5.95	4.72
25	11.8	2.2	4.92	3.58	1.78	3.68	2.5	7.0	2.3	8.05	4.85	4.15
26	7.82	2.15	4.71	3.49	1.75	3.08	1.9	5.85	2.32	7.08	4.45	3.62
27	6.22	2.0	5.3	3.48	2.72	5.8	1.65	6.28	2.25	6.2	4.18	3.3
28	9.0	2.2	5.71	3.5	2.85	3.65	1.95	9.05	2.05	5.9	3.82	3.5
29	7.6	....	8.2	3.15	4.75	3.6	2.75	7.45	2.02	5.0	3.45	3.42
30	6.3	....	9.05	2.95	3.48	3.45	5.4	9.1	2.35	4.55	3.22	3.3
31	5.85	....	10.5	....	3.28	....	4.35	7.55	....	4.2	....	3.35
1907												
1	5.78	3.15	4.25	8.75	4.00	5.55	3.44	1.62	1.50	2.64	1.32	3.68
2	6.55	3.52	4.88	8.52	4.01	21.00	3.14	1.64	1.32	2.42	1.88	3.35
3	7.35	3.45	5.40	5.02	4.20	15.14	3.10	1.49	1.25	2.38	2.75	3.14
4	6.38	3.42	6.70	4.50	3.92	11.25	2.70	1.68	3.28	2.08	3.09	2.88
5	5.40	3.48	6.79	3.92	3.88	8.10	2.58	1.48	4.28	1.92	2.74	2.60
6	5.15	3.60	5.50	3.68	3.62	7.40	2.46	1.31	2.50	1.82	3.10	2.58
7	4.68	3.48	5.10	5.75	6.55	6.20	2.42	1.48	1.56	1.70	2.58	2.48
8	4.38	3.35	4.65	8.20	5.65	5.78	2.64	1.55	1.58	1.62	2.35	2.38
9	4.12	3.22	4.85	12.40	9.90	5.57	2.26	1.52	1.66	1.72	2.08	2.65
10	3.80	3.75	4.57	14.10	7.62	5.52	2.30	1.79	1.59	1.66	2.18	5.00
11	3.52	4.10	4.75	12.30	6.35	7.10	2.06	2.30	1.62	1.58	2.50	11.00
12	3.65	4.22	4.88	9.00	5.30	6.20	2.08	2.36	1.82	1.68	2.56	10.20
13	3.60	4.35	6.00	7.50	5.20	5.98	2.14	2.55	2.00	1.74	3.34	8.70
14	3.65	4.22	5.90	7.50	4.65	10.02	2.18	2.56	2.38	1.58	3.42	8.70
15	3.55	4.08	7.45	7.75	4.30	16.89	2.14	2.05	1.88	1.69	2.85	9.00
16	4.10	3.98	7.52	5.25	4.06	15.10	1.86	1.71	1.82	1.58	2.58	7.60
17	4.65	3.75	6.58	4.70	4.92	9.00	1.98	1.65	1.62	1.40	2.52	6.30
18	6.21	3.62	5.82	4.42	4.42	7.30	1.98	2.11	1.56	1.52	2.40	6.00
19	7.65	3.58	5.28	4.25	4.00	5.95	1.90	1.68	1.59	1.29	3.72	5.15
20	7.70	3.38	5.15	4.20	3.70	5.30	3.18	1.48	1.52	1.30	3.68	4.76
21	7.40	3.40	4.90	4.00	3.45	4.85	3.05	1.54	1.58	1.36	3.62	4.20
22	6.68	3.38	5.80	3.80	3.10	4.20	2.28	1.58	1.71	1.25	4.20	3.98
23	5.30	3.15	5.60	3.75	3.02	4.50	2.12	1.38	4.20	1.32	4.88	5.86
24	4.48	3.05	5.00	5.50	2.85	4.82	1.90	1.74	19.00	1.30	9.30	13.60
25	3.90	2.88	4.45	5.02	2.85	4.35	1.81	1.69	11.60	1.21	10.70	12.50

Daily gage height, in feet, of James River at Cartersville, Va., for 1906-1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	3.85	3.68	4.10	5.42	2.90	4.35	1.72	1.64	6.68	1.24	9.00	10.00
27	3.55	3.78	3.70	5.48	2.98	3.90	1.71	1.92	4.70	1.82	7.50	7.82
28	3.30	4.02	3.62	5.08	2.95	4.80	1.74	2.19	3.76	1.22	5.75	7.52
29	3.00	....	3.42	4.58	2.62	4.10	1.59	1.90	3.38	1.58	4.98	7.12
30	3.02	....	3.15	4.35	2.52	3.85	1.50	1.62	3.16	1.60	4.00	5.75
31	3.15	....	3.15	....	2.65	....	1.68	1.48	....	1.36	....	6.48
1908												
1	6.67	3.77	5.79	6.08	4.28	4.35	2.41	2.75	2.68	2.82	6.78	2.18
2	6.53	3.87	5.17	10.63	4.05	3.94	2.92	2.40	2.44	2.04	5.25	2.28
3	5.77	3.93	5.07	10.37	4.12	3.75	2.48	1.98	2.20	1.74	4.30	2.18
4	5.21	3.80	6.27	9.02	4.02	5.72	2.68	1.78	2.05	1.68	3.81	2.02
5	5.56	3.67	6.00	7.65	3.91	7.31	2.48	1.84	1.94	1.62	3.32	2.11
6	5.20	3.69	7.65	6.26	4.02	5.88	2.38	1.79	8.20	1.50	3.04	2.18
7	5.20	3.87	9.00	5.66	5.70	6.46	2.78	1.69	6.88	1.50	2.90	3.92
8	14.13	3.73	10.45	5.25	8.02	5.06	3.10	1.76	4.52	1.50	2.75	4.72
9	8.65	3.57	9.07	4.89	9.06	4.36	2.92	1.75	3.32	1.48	2.58	3.58
10	7.00	3.53	8.33	4.61	7.84	4.18	2.78	2.43	2.78	1.53	2.42	3.15
11	5.66	3.67	7.21	4.42	6.21	4.05	2.60	2.18	2.52	1.68	2.48	3.15
12	11.70	3.67	6.56	4.25	5.42	3.88	2.40	2.12	2.31	1.64	2.41	3.80
13	17.28	4.47	6.10	4.19	4.98	3.70	1.96	2.08	2.12	1.64	2.38	4.62
14	19.35	6.70	5.64	4.09	4.38	3.66	1.81	2.15	1.94	1.71	2.29	4.28
15	11.45	12.77	5.20	4.07	3.98	3.79	1.80	1.88	1.85	1.81	2.68	4.32
16	9.06	19.04	4.95	4.18	3.62	6.86	1.68	1.72	1.78	1.66	3.10	3.82
17	7.47	19.65	4.84	4.32	3.30	5.02	1.44	1.55	1.71	1.59	2.68	3.42
18	6.57	11.13	4.75	3.97	3.55	4.75	1.39	1.52	1.62	1.50	2.68	3.15
19	6.03	8.85	4.87	4.02	4.14	4.38	1.36	1.36	1.54	1.40	2.51	2.98
20	5.39	8.67	5.49	4.15	4.92	3.30	1.31	1.72	1.46	1.42	2.78	2.88
21	5.03	7.63	5.99	3.98	8.18	3.18	1.31	1.70	1.44	1.40	3.82	2.78
22	4.67	6.67	6.13	3.83	9.36	3.96	1.35	1.39	1.42	1.41	3.80	2.75
23	4.47	6.13	5.83	3.63	8.03	3.25	1.69	1.34	1.46	1.42	3.48	2.90
24	4.11	5.27	6.05	3.55	8.48	3.08	2.78	1.26	1.46	1.75	3.12	2.94
25	3.95	4.96	5.80	3.37	7.26	3.38	2.74	1.38	1.39	3.72	2.92	3.30
26	3.75	6.23	5.57	3.45	6.35	2.92	2.58	13.84	1.39	6.14	2.78	3.48
27	4.53	8.17	5.29	3.42	5.46	2.55	3.98	9.84	1.38	4.35	2.72	3.92
28	4.40	6.54	4.72	3.61	5.02	2.42	5.08	7.04	2.34	3.78	2.50	4.51
29	4.30	6.10	4.63	3.97	5.16	2.28	3.66	5.48	4.93	5.12	2.38	4.96
30	4.53	....	4.37	3.78	4.95	2.42	4.04	3.87	3.22	8.20	2.28	6.26
31	4.00	....	4.49	....	5.58	....	3.25	3.18	....	8.41	....	7.61
1909												
1	9.15	4.52	6.12	5.16	4.75	4.98	3.32	1.42	1.18	1.24	1.32	1.24
2	8.38	3.86	5.70	4.85	6.00	6.28	3.45	3.02	1.14	1.18	1.26	1.22
3	7.45	3.75	5.20	4.50	5.80	5.85	3.50	2.68	1.10	1.08	1.24	1.18
4	6.18	3.70	5.58	4.26	6.82	6.96	3.30	2.08	1.04	1.06	1.26	1.16
5	8.20	3.66	5.55	4.12	5.18	9.32	3.05	1.89	1.01	1.04	1.29	1.18
6	12.22	3.55	5.50	3.98	4.68	8.02	2.86	1.88	1.06	1.06	1.32	1.26
7	10.68	3.45	6.18	3.85	4.34	6.35	3.10	1.95	1.02	1.08	1.26	1.28
8	8.98	3.42	5.98	3.52	4.04	5.48	3.18	1.92	1.06	1.06	1.26	1.34
9	7.40	4.22	5.72	3.36	3.81	5.05	2.98	1.68	1.10	1.06	1.19	1.38
10	6.20	7.02	5.75	3.15	3.63	7.12	3.15	1.70	1.46	1.06	1.22	1.42
11	5.32	9.24	5.79	3.12	3.98	6.56	2.92	1.68	1.96	1.04	1.32	1.36
12	4.88	11.25	5.55	3.15	6.12	6.64	2.42	1.42	1.66	1.28	1.31	1.32
13	4.41	9.02	5.26	3.20	5.55	6.00	2.22	1.44	1.36	2.68	1.28	1.40
14	4.17	7.58	5.05	6.15	4.78	5.05	2.26	1.42	1.20	3.10	1.27	4.78
15	4.14	6.08	4.76	11.95	4.22	4.70	2.12	1.38	1.31	2.58	1.26	5.84
16	4.25	5.68	4.59	15.68	3.88	4.85	2.08	1.52	1.32	2.27	1.25	6.18
17	5.55	5.38	4.47	9.02	3.52	4.50	2.02	1.98	1.38	2.18	1.32	4.26
18	6.86	5.10	4.10	7.98	3.38	5.35	1.94	2.20	1.55	1.64	1.32	3.44
19	7.45	5.95	3.92	6.22	3.06	5.58	1.82	2.04	1.88	1.51	1.34	2.98
20	6.64	7.78	3.84	5.62	2.88	5.05	1.72	1.82	2.84	1.50	1.34	2.54

Daily gage height, in feet, of James River at Cartersville, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	6.68	7.68	3.72	5.28	3.55	3.48	1.84	1.68	2.42	1.36	1.30	2.26
22	6.84	6.05	3.92	4.88	8.10	3.32	1.72	1.52	2.06	1.38	1.32	2.29
23	7.74	6.86	4.16	4.68	11.60	3.14	1.58	1.40	1.88	1.38	1.31	2.02
24	8.12	7.48	4.18	5.00	8.82	3.01	1.54	1.36	1.68	1.34	1.34	1.88
25	7.75	8.98	5.20	5.48	7.15	2.98	1.52	1.34	1.48	1.36	1.36	1.54
26	7.38	8.32	8.00	5.68	6.46	3.00	1.50	1.28	1.42	1.35	1.34	1.54
27	6.68	8.11	8.86	5.22	7.48	2.98	1.40	1.30	1.24	1.34	1.24	1.72
28	5.82	7.52	8.26	4.74	9.08	3.08	1.60	1.28	1.18	1.28	1.26	1.75
29	5.32	....	7.02	4.35	7.80	3.35	1.91	1.28	1.26	1.28	1.26	1.58
30	5.15	....	6.15	4.12	6.88	3.70	1.66	1.22	1.24	1.29	1.25	1.48
31	4.86	....	5.58	....	5.28	....	1.58	1.16	....	1.28	....	1.40
1910												
1	1.45	3.40	7.79	2.17	4.00	2.13	3.03	1.55	1.15	0.79	1.18	1.27
2	1.65	3.06	8.65	2.06	3.67	2.00	2.77	1.53	1.40	.84	1.18	1.16
3	2.01	3.18	9.37	2.23	3.43	1.89	2.61	1.79	1.35	.86	1.32	1.11
4	1.97	3.73	7.63	2.43	3.20	1.83	2.55	1.44	1.43	.78	1.68	1.08
5	2.04	4.26	6.61	2.51	2.93	1.76	3.60	1.39	1.80	.71	1.58	1.08
6	1.91	3.97	6.09	2.41	2.84	1.99	3.07	1.32	1.57	.69	1.40	1.28
7	3.23	3.45	5.15	2.27	2.73	2.07	2.73	1.24	1.60	.72	1.26	1.42
8	3.76	3.17	4.67	2.26	2.79	2.03	3.60	1.17	1.58	1.38	1.28	1.58
9	5.10	3.23	4.37	2.26	2.74	2.07	4.57	1.09	1.46	2.82	1.20	1.51
10	4.57	3.30	4.07	2.17	2.73	2.63	3.70	1.19	1.16	4.06	1.21	1.42
11	3.73	2.94	3.83	2.06	2.77	3.71	2.73	1.23	1.09	2.28	1.18	1.40
12	3.47	2.91	3.61	2.01	2.59	5.93	4.05	1.06	1.02	1.86	1.12	1.42
13	2.97	2.90	3.37	2.31	2.57	10.45	3.35	1.03	1.04	1.56	1.00	1.18
14	2.73	2.79	3.23	2.46	2.53	12.95	4.50	1.06	1.07	1.34	.92	1.12
15	2.63	2.78	3.15	2.63	2.43	17.01	3.87	1.19	1.02	1.27	1.11	1.26
16	2.45	3.20	3.10	3.23	2.33	18.65	3.36	1.29	1.06	1.08	1.02	1.24
17	2.27	3.51	2.94	7.03	2.24	19.89	3.75	1.29	1.01	.99	1.11	1.28
18	2.43	7.50	2.87	10.30	2.31	16.85	4.83	1.21	1.00	.96	1.10	1.34
19	2.46	10.91	2.74	9.35	2.21	11.47	8.10	1.15	.89	.96	1.08	1.38
20	2.43	10.33	2.67	8.35	2.16	8.63	8.66	1.26	.98	1.76	1.00	1.37
21	3.15	7.28	2.60	6.70	2.14	6.87	8.60	1.19	.94	2.25	1.02	1.30
22	10.99	6.67	2.57	5.55	2.28	5.67	4.45	1.43	.89	1.88	1.02	1.25
23	9.80	6.25	2.56	5.00	2.67	4.45	3.85	1.62	.97	2.75	1.00	1.05
24	7.77	5.78	2.47	4.85	2.63	3.73	3.79	1.27	.91	2.12	1.08	1.88
25	6.77	5.47	2.35	5.13	3.01	3.63	3.57	1.17	.88	1.76	1.09	1.98
26	5.03	4.90	2.26	4.67	3.58	3.53	2.47	1.16	.80	1.81	1.08	2.18
27	4.29	4.57	2.25	4.27	3.43	3.45	2.33	1.21	.81	1.58	.96	2.08
28	3.87	4.11	2.23	4.09	2.75	3.44	2.09	1.12	.82	1.45	1.09	2.31
29	3.73	....	2.17	4.15	2.63	3.39	1.87	1.02	.78	1.32	1.08	2.34
30	3.67	....	2.25	4.09	2.35	3.21	1.71	.90	.68	1.39	1.18	2.40
31	3.61	....	2.16	....	2.16	....	1.63	1.06	....	1.32	....	2.52
1911												
1	3.6	11.3	2.4	5.0	3.4	1.35	....	0.50	7.6	0.74	1.7	2.7
2	7.7	8.0	2.3	4.9	3.2	1.25	0.92	.50	5.4	.69	1.6	2.6
3	8.9	6.7	2.3	4.4	3.1	1.1	.84	.66	4.6	.62	1.5	2.4
4	16.2	5.4	2.2	4.5	3.0	1.1	.76	.61	3.5	.78	1.45	2.1
5	13.0	4.8	2.1	7.0	2.8	1.45	.82	.59	3.0	.92	1.85	2.2
6	9.2	3.9	2.1	11.8	2.8	1.8	.74	.58	2.5	.79	1.85	2.0
7	8.2	3.7	2.2	10.7	2.7	1.6	.74	1.15	2.6	.82	2.0	1.9
8	6.0	3.7	2.8	9.3	2.6	1.7	1.7	1.0	1.35	.80	3.0	1.9
9	4.2	3.6	4.8	8.9	2.6	1.9	2.8	1.0	1.1	.82	6.3	1.8
10	4.0	4.2	4.4	8.0	2.6	1.9	2.2	.78	1.1	.89	4.8	1.7
11	3.2	3.7	5.1	7.2	2.5	1.9	1.35	.80	1.1	1.1	3.8	1.6
12	2.9	4.0	5.7	6.6	2.4	1.7	1.25	.76	1.4	.98	3.4	1.5
13	2.8	4.6	6.3	6.0	2.3	1.45	1.1	.72	1.3	1.0	3.0	1.6
14	2.7	4.1	5.6	5.2	2.2	1.4	1.45	.80	1.3	1.1	2.9	1.6
15	2.6	3.7	5.1	5.1	2.1	1.3	1.3	.79	1.1	1.0	2.7	1.6

Daily gage height, in feet, of James River at Cartersville, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	3.85	3.68	4.10	5.42	2.90	4.35	1.72	1.64	6.68	1.24	9.00	10.00
27	3.55	3.78	3.70	5.48	2.98	3.90	1.71	1.92	4.70	1.32	7.50	7.82
28	3.30	4.02	3.62	5.08	2.95	4.80	1.74	2.19	3.76	1.22	5.75	7.52
29	3.00	....	3.42	4.58	2.62	4.10	1.59	1.90	3.38	1.58	4.98	7.12
30	3.02	....	3.15	4.35	2.52	3.85	1.50	1.62	3.16	1.60	4.00	5.75
31	3.15	....	3.15	....	2.65	....	1.68	1.48	....	1.36	....	6.48
1908												
1	6.67	3.77	5.79	6.08	4.28	4.35	2.41	2.75	2.68	2.32	6.78	2.18
2	6.53	3.87	5.17	10.63	4.05	3.94	2.92	2.40	2.44	2.04	5.25	2.28
3	5.77	3.98	5.07	10.37	4.12	3.75	2.48	1.98	2.20	1.74	4.30	2.18
4	5.21	3.80	6.27	9.02	4.02	5.72	2.68	1.78	2.05	1.68	3.81	2.02
5	5.55	3.67	6.00	7.65	3.91	7.31	2.48	1.84	1.94	1.62	3.32	2.11
6	5.20	3.69	7.65	6.26	4.02	5.88	2.38	1.79	8.20	1.50	3.04	2.18
7	5.20	3.87	9.00	5.66	5.70	6.46	2.78	1.69	6.88	1.50	2.90	3.92
8	14.13	3.73	10.45	5.25	8.02	5.06	3.10	1.76	4.52	1.50	2.75	4.72
9	8.65	3.57	9.07	4.89	9.06	4.36	2.92	1.75	3.32	1.48	2.58	3.58
10	7.00	3.53	8.33	4.61	7.84	4.18	2.78	2.43	2.78	1.53	2.42	3.15
11	5.66	3.67	7.21	4.42	6.21	4.05	2.60	2.18	2.52	1.68	2.48	3.15
12	11.70	3.67	6.56	4.25	5.42	3.88	2.40	2.12	2.31	1.64	2.41	3.80
13	17.28	4.47	6.10	4.19	4.98	3.70	1.96	2.68	2.12	1.64	2.38	4.62
14	19.35	6.70	5.64	4.09	4.38	3.66	1.81	2.15	1.94	1.71	2.29	4.28
15	11.45	12.77	5.20	4.07	3.98	3.79	1.80	1.88	1.85	1.81	2.68	4.32
16	9.05	19.04	4.95	4.18	3.62	6.86	1.68	1.72	1.78	1.66	3.10	3.82
17	7.47	19.65	4.84	4.32	3.30	5.02	1.44	1.55	1.71	1.59	2.68	3.42
18	6.57	11.13	4.75	3.97	3.55	4.75	1.39	1.52	1.62	1.50	2.68	3.15
19	6.03	8.85	4.87	4.02	4.14	4.38	1.36	1.36	1.54	1.40	2.51	2.98
20	5.39	8.67	5.49	4.15	4.92	3.30	1.31	1.72	1.46	1.42	2.78	2.88
21	5.03	7.63	5.99	3.98	8.18	3.18	1.31	1.70	1.44	1.40	3.82	2.78
22	4.67	6.67	6.13	3.83	9.36	3.96	1.35	1.39	1.42	1.41	3.80	2.75
23	4.47	6.13	5.83	3.63	8.03	3.25	1.69	1.34	1.46	1.42	3.48	2.90
24	4.11	5.27	6.05	3.55	8.48	3.68	2.78	1.26	1.46	1.75	3.12	2.94
25	3.95	4.96	5.80	3.37	7.26	3.38	2.74	1.38	1.39	3.72	2.92	3.30
26	3.75	6.23	5.57	3.45	6.35	2.92	2.58	13.84	1.39	6.14	2.78	3.48
27	4.53	8.17	5.29	3.42	5.46	2.55	3.98	9.84	1.38	4.35	2.72	3.92
28	4.40	6.54	4.72	3.61	5.02	2.42	5.08	7.04	2.34	3.78	2.50	4.51
29	4.30	6.10	4.63	3.97	5.16	2.28	3.66	5.48	4.93	5.12	2.38	4.96
30	4.53	....	4.37	3.78	4.95	2.42	4.04	3.87	3.22	8.20	2.28	6.26
31	4.00	....	4.49	....	5.58	....	3.25	3.18	....	8.41	....	7.61
1909												
1	9.15	4.52	6.12	5.16	4.75	4.98	3.32	1.42	1.18	1.24	1.32	1.24
2	8.38	3.86	5.70	4.85	6.00	6.28	3.45	3.02	1.14	1.18	1.26	1.22
3	7.45	3.75	5.20	4.50	5.80	5.85	3.50	2.68	1.10	1.08	1.24	1.18
4	6.18	3.70	5.58	4.26	6.82	6.96	3.30	2.08	1.04	1.06	1.26	1.16
5	8.20	3.66	5.55	4.12	5.18	9.32	3.05	1.89	1.01	1.04	1.29	1.18
6	12.22	3.55	5.50	3.98	4.68	8.02	2.86	1.88	1.06	1.06	1.32	1.26
7	10.68	3.45	6.18	3.85	4.34	6.55	3.10	1.95	1.02	1.08	1.26	1.28
8	8.98	3.42	5.98	3.52	4.04	5.48	3.18	1.92	1.06	1.06	1.26	1.34
9	7.40	4.22	5.72	3.36	3.81	5.05	2.98	1.68	1.10	1.06	1.19	1.38
10	6.20	7.02	5.75	3.15	3.63	7.12	3.15	1.70	1.46	1.06	1.22	1.42
11	5.32	9.24	5.79	3.12	3.98	6.56	2.92	1.68	1.96	1.04	1.32	1.36
12	4.88	11.25	5.55	3.15	6.12	6.64	2.42	1.42	1.66	1.28	1.31	1.32
13	4.41	9.02	5.26	3.20	5.55	6.00	2.22	1.44	1.36	2.68	1.28	1.40
14	4.17	7.58	5.05	6.15	4.78	5.05	2.26	1.42	1.20	3.10	1.27	4.78
15	4.14	6.08	4.76	11.95	4.22	4.70	2.12	1.38	1.31	2.58	1.26	5.84
16	4.25	5.68	4.59	15.68	3.88	4.85	2.08	1.52	1.32	2.27	1.25	6.18
17	5.55	5.38	4.47	9.02	3.52	4.50	2.02	1.98	1.38	2.18	1.32	4.26
18	6.86	5.10	4.10	7.98	3.38	5.35	1.94	2.20	1.55	1.64	1.32	3.44
19	7.45	5.95	3.92	6.22	3.06	5.58	1.82	2.04	1.88	1.51	1.34	2.98
20	6.64	7.78	3.84	5.62	2.88	5.05	1.72	1.82	2.84	1.50	1.34	2.54

Daily gage height, in feet, of James River at Cartersville, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	6.68	7.68	3.72	5.28	3.55	3.48	1.84	1.68	2.42	1.36	1.30	2.26
22	6.84	6.05	3.92	4.88	8.10	3.32	1.72	1.52	2.06	1.38	1.32	2.29
23	7.74	6.86	4.16	4.68	11.60	3.14	1.58	1.40	1.88	1.38	1.31	2.02
24	8.12	7.48	4.18	5.00	8.82	3.01	1.54	1.36	1.68	1.34	1.34	1.88
25	7.75	8.98	5.20	5.48	7.15	2.98	1.52	1.34	1.48	1.36	1.36	1.54
26	7.38	8.32	8.00	5.68	6.46	3.00	1.50	1.28	1.42	1.35	1.34	1.54
27	6.68	8.11	8.86	5.22	7.48	2.98	1.40	1.30	1.24	1.34	1.24	1.72
28	5.82	7.52	8.26	4.74	9.08	3.08	1.60	1.28	1.18	1.28	1.26	1.75
29	5.32	....	7.02	4.35	7.80	3.35	1.91	1.28	1.26	1.28	1.26	1.58
30	5.15	....	6.15	4.12	6.88	3.70	1.66	1.22	1.24	1.29	1.25	1.48
31	4.86	....	5.58	....	5.28	....	1.58	1.16	....	1.28	....	1.40
1910												
1	1.45	3.40	7.79	2.17	4.00	2.13	3.03	1.55	1.15	0.79	1.18	1.27
2	1.65	3.06	8.65	2.06	3.67	2.00	2.77	1.53	1.40	.84	1.18	1.16
3	2.01	3.13	9.37	2.23	3.43	1.89	2.61	1.79	1.35	.86	1.32	1.11
4	1.97	3.73	7.63	2.43	3.20	1.83	2.55	1.44	1.43	.78	1.68	1.08
5	2.04	4.26	6.61	2.51	2.93	1.76	3.60	1.39	1.80	.71	1.58	1.08
6	1.91	3.97	6.09	2.41	2.84	1.99	3.07	1.32	1.57	.69	1.40	1.28
7	3.23	3.45	5.15	2.27	2.73	2.07	2.73	1.24	1.60	.72	1.26	1.42
8	3.76	3.17	4.67	2.26	2.79	2.08	3.60	1.17	1.58	1.38	1.28	1.58
9	5.10	3.23	4.37	2.26	2.74	2.07	4.57	1.09	1.46	2.82	1.20	1.51
10	4.57	3.30	4.07	2.17	2.78	2.63	3.70	1.19	1.16	4.06	1.21	1.42
11	3.78	2.94	3.88	2.06	2.77	3.71	2.73	1.23	1.09	2.28	1.18	1.40
12	3.47	2.91	3.61	2.01	2.59	5.93	4.05	1.06	1.02	1.86	1.12	1.42
13	2.97	2.90	3.37	2.31	2.57	10.45	3.35	1.03	1.04	1.56	1.00	1.18
14	2.78	2.79	3.23	2.46	2.53	12.95	4.50	1.06	1.07	1.34	.92	1.12
15	2.63	2.78	3.15	2.63	2.43	17.01	3.87	1.19	1.02	1.27	1.11	1.26
16	2.45	3.20	3.10	3.23	2.33	18.65	3.36	1.29	1.06	1.08	1.02	1.24
17	2.27	3.51	2.94	7.03	2.24	19.89	3.75	1.29	1.01	.99	1.11	1.28
18	2.43	7.50	2.87	10.30	2.31	16.85	4.83	1.21	1.00	.96	1.10	1.34
19	2.46	10.91	2.74	9.35	2.21	11.47	8.10	1.15	.89	.98	1.08	1.38
20	2.43	10.33	2.67	8.35	2.16	8.63	8.66	1.26	.98	1.76	1.00	1.37
21	3.15	7.28	2.60	6.70	2.14	6.87	8.60	1.19	.94	2.25	1.02	1.30
22	10.99	6.67	2.57	5.55	2.23	5.67	4.45	1.43	.89	1.88	1.02	1.25
23	9.80	6.25	2.56	5.00	2.67	4.45	3.85	1.62	.97	2.75	1.00	1.05
24	7.77	5.73	2.47	4.85	2.63	3.73	3.79	1.27	.91	2.12	1.08	1.88
25	6.77	5.47	2.35	5.13	3.01	3.63	3.57	1.17	.88	1.76	1.09	1.98
26	5.03	4.90	2.26	4.67	3.58	3.53	2.47	1.16	.80	1.81	1.08	2.18
27	4.29	4.57	2.25	4.27	3.43	3.45	2.33	1.21	.81	1.58	.96	2.08
28	3.87	4.11	2.23	4.09	2.75	3.44	2.09	1.12	.82	1.45	1.09	2.31
29	3.73	....	2.17	4.15	2.63	3.39	1.87	1.02	.78	1.32	1.08	2.34
30	3.67	....	2.25	4.09	2.35	3.21	1.71	.90	.68	1.39	1.18	2.40
31	3.61	....	2.16	....	2.16	....	1.63	1.06	....	1.82	....	2.52
1911												
1	3.6	11.3	2.4	5.0	3.4	1.35	....	0.50	7.6	0.74	1.7	2.7
2	7.7	8.0	2.3	4.9	3.2	1.25	0.92	.50	5.4	.69	1.6	2.6
3	8.9	6.7	2.3	4.4	3.1	1.1	.84	.66	4.6	.62	1.5	2.4
4	16.2	5.4	2.2	4.5	3.0	1.1	.76	.61	3.5	.78	1.45	2.1
5	13.0	4.8	2.1	7.0	2.8	1.45	.82	.59	3.0	.92	1.35	2.2
6	9.2	3.9	2.1	11.8	2.8	1.8	.74	.58	2.5	.79	1.35	2.0
7	8.2	3.7	2.2	10.7	2.7	1.6	.74	1.15	2.6	.82	2.0	1.9
8	6.0	3.7	2.8	9.3	2.6	1.7	1.7	1.0	1.35	.80	3.0	1.9
9	4.2	3.6	4.8	8.9	2.6	1.9	2.8	1.0	1.1	.82	6.3	1.8
10	4.0	4.2	4.4	8.0	2.6	1.9	2.2	.78	1.1	.89	4.8	1.7
11	3.2	3.7	5.1	7.2	2.5	1.9	1.35	.80	1.1	1.1	3.8	1.6
12	2.9	4.0	5.7	6.6	2.4	1.7	1.25	.76	1.4	.98	3.4	1.5
13	2.8	4.6	6.3	6.0	2.3	1.45	1.1	.72	1.3	1.0	3.0	1.6
14	2.7	4.1	5.6	5.2	2.2	1.4	1.45	.80	1.3	1.1	2.9	1.6
15	2.6	3.7	5.1	5.1	2.1	1.3	1.3	.79	1.1	1.0	2.7	1.6

Daily gage height, in feet, of James River at Cartersville, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
16	2.6	3.3	4.9	5.6	1.9	1.2	1.2	1.7	1.4	.99	2.7	2.8
17	2.9	3.2	4.7	7.2	2.0	1.2	1.15	1.5	1.5	1.1	2.8	7.4
18	2.8	3.1	4.2	6.6	1.9	1.15	1.3	1.4	1.15	3.6	2.7	4.9
19	2.6	3.4	4.0	5.8	1.7	1.1	.91	.90	1.1	6.8	2.8	4.1
20	2.5	2.8	3.6	6.0	1.6	1.1	.86	.88	1.1	8.8	2.8	3.2
21	2.4	2.7	3.8	5.7	1.6	1.15	.88	.88	1.3	5.0	2.8	3.0
22	2.5	3.1	4.2	5.5	1.5	1.1	.69	.72	1.1	4.8	3.0	3.1
23	2.9	3.0	4.2	5.4	1.35	1.05	.71	.50	1.15	4.2	2.8	7.4
24	3.7	2.9	4.0	5.0	1.5	.98	.62	.54	1.1	3.7	2.7	8.2
25	5.0	2.7	3.5	4.6	1.4	1.3	.58	.52	.98	3.0	2.6	9.2
26	4.5	2.6	3.4	4.2	1.35	1.7	.72	.72	.81	2.7	2.5	7.7
27	4.1	2.5	3.7	3.9	1.3	1.5	.59	.74	.84	2.4	2.4	7.5
28	3.6	2.4	4.2	3.7	1.3	1.2	.57	.76	.80	2.2	2.8	7.0
29	3.5	....	4.4	3.5	1.25	1.1	.61	.90	.78	2.0	4.0	6.6
30	3.6	....	4.8	3.5	1.2	.98	.58	1.2	.78	1.8	3.2	5.8
31	5.4	....	4.6	....	1.2	....	.62	2.2	....	1.7	....	....
1912												
1	6.1	5.2	7.7	10.1	3.9	2.9	3.1	1.1	0.62	2.5	1.1	1.3
2	5.8	5.4	6.0	9.0	3.8	2.8	3.0	1.1	.61	1.9	1.05	1.35
3	6.1	4.3	5.3	8.6	3.4	2.5	2.4	1.15	.57	1.7	1.1	1.3
4	5.2	4.1	4.6	9.4	3.3	2.5	2.5	1.2	.56	1.5	1.1	1.5
5	4.5	3.6	4.2	8.2	3.2	2.4	2.4	1.2	.58	1.45	1.1	1.7
6	3.7	3.4	4.1	7.2	3.2	2.2	2.3	1.05	.61	1.4	1.05	1.9
7	3.6	3.3	4.2	6.7	3.5	2.6	2.1	1.0	.60	1.3	1.2	2.0
8	3.2	3.2	4.6	6.0	3.9	2.7	1.9	1.0	.68	1.15	10.6	1.9
9	2.8	2.8	5.1	5.5	4.1	2.5	2.2	.94	1.05	1.1	6.6	1.7
10	2.7	2.6	6.0	5.1	3.6	2.0	1.8	.91	.98	1.1	6.1	1.6
11	2.8	2.4	5.2	4.7	3.7	2.0	1.7	.98	.92	1.05	4.1	1.7
12	2.8	2.5	5.9	4.4	13.8	1.8	1.8	1.0	.74	1.0	3.3	1.7
13	3.2	2.5	12.2	4.3	21.4	1.6	1.7	.92	.69	1.0	2.7	1.7
14	4.1	2.3	11.0	4.4	18.0	1.5	1.7	.94	.64	1.15	2.5	1.6
15	5.7	2.2	14.3	4.4	11.8	1.5	1.7	.92	.58	1.2	2.5	1.5
16	5.7	2.3	21.4	4.3	11.8	1.45	2.2	.92	.54	1.25	2.4	1.4
17	5.8	2.4	19.0	4.3	14.5	2.6	2.1	1.2	.56	1.2	2.3	1.4
18	5.8	2.8	13.5	4.3	13.9	2.5	1.7	1.4	.64	1.0	2.0	1.5
19	6.2	3.9	9.4	5.6	10.6	2.4	1.9	1.5	1.05	1.15	1.9	1.5
20	6.2	3.8	7.8	4.6	8.1	2.3	2.2	.94	1.3	1.15	1.9	1.8
21	6.3	4.0	6.9	4.4	6.6	1.8	2.1	.88	1.2	1.2	1.6	1.6
22	6.2	8.4	6.5	4.3	5.9	1.8	1.9	.84	1.1	1.25	1.5	1.4
23	5.6	8.7	6.1	4.3	5.4	2.0	1.2	.82	1.05	1.3	1.5	1.2
24	4.3	10.1	8.7	4.1	4.7	2.3	1.2	.82	11.1	1.45	1.4	1.4
25	3.8	8.8	10.1	3.7	4.4	2.0	1.4	.74	12.7	1.45	1.4	1.5
26	3.4	6.9	11.6	3.5	4.1	1.9	1.5	.70	5.7	1.35	1.35	1.45
27	3.4	12.6	11.5	3.3	3.8	1.9	1.7	.64	4.3	1.25	1.4	1.6
28	3.3	10.2	9.4	3.4	3.5	3.2	1.4	.59	4.3	1.1	1.4	1.7
29	3.3	9.7	14.5	3.6	3.2	2.9	1.05	.63	4.0	1.15	1.4	1.7
30	4.1	....	19.6	3.8	3.1	2.8	1.05	.65	2.5	1.1	1.3	2.4
31	5.1	....	16.3	....	3.3	....	1.1	.64	....	1.1	....	4.4
1913												
1	5.7	4.1	4.4	8.1	3.2	12.2	2.7	1.6	1.2	1.3	2.6	2.3
2	7.2	3.8	4.8	6.1	2.9	6.0	2.4	1.45	1.1	1.7	2.5	2.7
3	5.6	3.4	4.6	5.2	2.8	5.1	2.3	1.5	1.1	1.25	2.1	3.5
4	5.3	3.9	4.1	4.7	2.7	5.6	2.2	2.0	1.4	1.15	2.0	3.9
5	4.9	3.8	3.4	4.2	2.6	5.2	3.4	1.8	1.3	1.1	1.9	4.3
6	4.8	3.2	3.1	4.0	2.5	5.1	4.4	1.6	1.25	1.05	1.8	3.9
7	4.3	3.1	2.9	3.7	2.4	4.4	3.4	2.1	1.15	1.05	1.7	3.7
8	3.7	3.0	2.7	3.5	2.4	7.4	2.4	1.3	1.1	1.0	1.7	3.2
9	3.5	3.0	2.6	3.2	2.4	4.8	2.2	1.25	1.0	1.15	3.0	3.1
10	4.8	2.9	2.4	3.1	2.3	4.1	2.0	1.6	.88	1.3	13.5	3.1

Daily gage height, in feet, of James River at Cartersville, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	4.5	3.9	3.1	2.9	2.3	3.4	3.5	2.3	.95	2.0	10.2	3.0
12	4.1	2.8	3.6	5.3	2.2	3.2	2.1	2.2	.91	1.7	7.2	2.9
13	3.7	2.6	4.8	18.0	2.1	3.0	2.3	1.5	.90	1.5	6.3	2.8
14	3.5	2.4	12.5	16.0	2.1	2.8	2.8	2.7	.92	1.6	4.2	2.7
15	3.0	2.3	19.7	13.6	2.0	2.7	2.2	2.8	.94	1.6	3.8	2.5
16	2.9	2.2	18.9	18.0	2.0	2.5	2.2	2.7	.88	1.55	3.2	2.4
17	2.7	2.1	14.4	12.4	2.2	2.2	2.0	2.2	.78	1.4	5.1	2.4
18	2.7	1.9	10.1	9.7	2.6	2.0	1.8	1.9	.92	1.35	5.2	2.3
19	2.6	1.9	7.8	8.2	2.5	1.9	1.9	1.8	1.0	1.3	5.0	2.2
20	2.4	2.0	6.5	7.3	2.1	1.9	1.8	5.1	1.05	1.7	4.6	2.1
21	2.3	2.0	5.8	6.2	2.1	1.8	....	3.3	1.1	2.5	4.0	2.0
22	2.2	2.0	5.5	5.3	2.2	1.8	....	3.0	3.1	2.4	3.9	2.0
23	2.2	1.9	5.1	4.9	2.9	2.4	....	2.8	3.0	2.3	3.7	2.0
24	2.2	1.9	4.3	4.4	16.3	4.0	2.3	2.5	2.5	2.9	3.0	2.9
25	2.4	1.8	4.0	4.1	15.8	4.3	2.3	3.1	1.7	5.2	2.8	3.3
26	2.3	1.9	3.8	3.9	12.0	4.0	1.9	2.0	1.6	5.8	2.5	6.1
27	2.4	2.0	4.0	3.7	9.8	3.2	1.8	1.9	1.4	4.9	2.4	6.0
28	4.8	2.9	10.9	3.6	10.2	3.1	1.5	1.8	1.25	4.8	2.4	5.9
29	4.9	....	21.6	3.4	8.5	4.1	1.4	1.6	1.15	4.6	2.5	5.5
30	5.6	....	13.0	3.3	8.8	3.8	1.6	1.4	1.1	3.6	2.4	4.6
31	4.7	....	9.1	....	11.0	....	1.3	1.3	....	2.9	....	4.1
1914												
1	3.1	10.1	5.4	5.1	5.0	1.5	1.25	0.96	1.2	0.62	1.1	1.4
2	3.3	11.8	5.3	4.9	4.1	1.5	1.1	.94	1.05	.52	1.05	1.6
3	3.5	9.4	4.6	4.8	3.9	1.6	1.4	.98	.83	.51	1.05	4.5
4	10.6	7.2	4.6	4.7	3.8	1.45	1.25	.95	.80	.56	1.05	4.2
5	9.6	6.3	4.6	4.7	3.6	1.45	1.8	.96	.78	.69	.98	3.8
6	7.0	5.8	4.6	4.6	3.7	1.45	2.3	1.0	.72	.94	.96	8.9
7	5.7	7.6	4.8	4.5	3.6	1.45	2.3	.96	.70	1.0	.91	11.8
8	5.4	8.0	4.8	4.3	3.7	1.45	1.9	.82	.66	.96	.91	8.8
9	4.5	9.5	4.9	4.4	3.8	1.4	1.8	.85	.63	.83	.95	6.3
10	4.3	8.0	4.6	4.1	3.5	1.5	1.6	.71	.60	1.1	1.0	5.2
11	4.5	6.4	4.6	3.9	3.3	1.45	1.35	.68	.58	1.0	1.0	4.6
12	5.7	6.0	4.7	3.8	3.2	1.4	1.35	.80	.66	.96	1.1	4.3
13	5.9	6.0	4.8	3.7	3.2	1.35	1.5	.96	.72	.94	.98	4.0
14	5.8	4.6	5.2	3.6	3.1	1.4	1.7	.93	.72	.94	.96	4.6
15	4.3	4.4	5.0	3.8	3.0	1.35	1.8	1.05	.63	2.1	1.6	4.2
16	3.9	4.3	5.3	6.6	2.7	1.4	2.5	.92	.60	2.6	5.6	3.4
17	3.7	4.0	5.4	6.8	2.5	1.35	2.4	.88	.65	6.2	4.2	2.9
18	3.4	4.2	6.4	6.8	2.4	1.4	2.3	.71	.68	4.8	3.3	2.7
19	3.4	5.4	9.9	6.4	2.3	1.4	2.1	.66	.66	4.1	2.6	2.7
20	3.2	9.2	9.5	5.5	2.3	1.05	1.7	.74	.64	2.5	2.3	3.8
21	3.1	11.2	7.7	5.4	2.2	1.0	1.5	.66	.76	2.3	2.0	5.3
22	2.9	9.9	7.1	5.5	2.2	2.2	1.15	.66	.82	1.7	1.8	7.1
23	3.1	8.5	6.4	5.5	2.1	1.35	1.05	.76	.78	1.4	1.5	7.2
24	3.4	7.9	6.2	5.0	2.0	1.25	.97	.94	.74	1.35	1.5	6.9
25	7.7	7.0	6.1	4.5	1.9	1.15	1.0	.96	.76	1.35	1.4	5.4
26	5.9	6.9	5.2	4.5	1.8	1.4	.97	.84	.76	1.3	1.35	5.1
27	7.4	6.3	5.0	5.0	1.9	1.6	.97	1.3	.75	1.3	1.3	4.4
28	5.7	5.6	4.8	5.8	1.8	1.8	.89	1.5	.78	1.1	1.25	3.5
29	5.2	....	4.7	6.6	1.6	1.9	.87	1.45	.74	1.1	1.3	3.7
30	4.5	....	4.6	5.4	1.6	1.4	.97	1.35	.65	1.1	1.25	4.6
31	5.1	....	4.3	....	1.5	....	1.05	1.25	....	1.1	....	6.0

NOTE.—Ice formed Dec. 22-31, 1909, but river not frozen over. Floating ice in river Dec. 7-16 and 18-21, 1910. Gage stolen July 20 and replaced July 24, 1913.

Daily discharge, in second-feet, of James River at Cartersville, Va., for 1906–1914.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	10,248	11,269	3,920	21,008	5,330	4,700	5,550	5,506	13,064	9,990	7,710	5,770
2	8,742	8,550	4,280	19,620	5,288	9,910	3,780	7,245	11,296	6,670	7,020	5,440
3	7,475	8,310	4,532	15,710	5,120	6,946	3,280	6,900	9,155	10,700	6,560	5,120
4	52,820	6,394	26,100	13,120	5,120	4,679	3,185	5,078	7,758	34,400	6,030	4,910
5	33,670	6,900	19,785	11,134	4,910	3,680	4,490	4,595	6,716	45,300	5,770	4,910
6	29,980	6,670	16,010	10,040	5,078	3,580	4,240	3,880	5,880	32,600	5,550	4,740
7	18,650	6,210	12,565	9,280	5,015	3,640	4,322	2,900	5,374	23,700	5,330	4,490
8	13,400	5,880	10,040	8,430	7,360	3,580	3,780	5,374	4,910	16,500	5,120	4,450
9	11,215	5,726	8,742	8,190	6,210	3,640	3,185	5,506	4,490	14,800	4,950	4,380
10	9,530	6,555	7,710	11,485	5,330	3,420	2,710	7,830	4,280	11,700	4,800	4,180
11	8,070	5,550	6,670	10,352	5,330	3,090	2,710	7,176	3,580	9,880	5,020	4,180
12	7,475	5,162	6,210	10,820	4,952	2,900	2,710	7,015	3,880	8,120	5,220	4,490
13	7,360	4,805	5,880	10,690	4,700	2,710	2,862	9,832	4,490	6,950	5,220	4,240
14	7,590	5,120	5,594	9,530	4,595	2,805	2,620	7,176	5,880	6,100	4,870	4,080
15	8,118	4,805	6,210	25,750	3,980	3,185	2,386	5,440	4,595	5,810	4,600	3,980
16	8,070	4,490	21,110	23,660	4,180	2,995	2,170	8,598	4,280	5,330	4,800	3,880
17	7,830	4,280	14,245	16,615	4,040	3,480	2,710	11,836	3,980	5,160	4,060	3,880
18	7,710	4,120	15,710	15,320	3,880	4,280	2,900	23,388	3,640	5,770	4,450	7,360
19	7,590	4,240	12,924	12,700	3,780	3,242	2,710	15,115	3,780	18,300	22,000	7,240
20	7,130	3,680	21,280	10,690	3,720	3,440	2,674	11,134	4,240	75,800	25,600	19,600
21	6,785	4,080	15,710	9,655	3,880	10,820	4,952	12,025	3,700	84,800	28,600	17,300
22	6,256	4,240	14,622	8,958	3,480	16,010	4,080	9,832	3,520	60,300	26,400	13,000
23	6,166	4,385	11,944	8,190	5,120	15,410	5,288	14,535	3,480	33,700	16,800	11,000
24	7,710	4,080	10,300	7,710	3,280	8,958	6,210	9,280	3,880	24,200	12,800	9,580
25	30,340	3,880	10,092	6,854	3,052	7,084	4,490	15,860	4,080	19,100	9,910	8,190
26	18,394	3,780	9,555	6,647	2,995	5,726	3,280	11,215	4,120	16,100	8,910	6,950
27	13,596	3,480	11,080	6,624	4,952	11,080	2,805	13,764	3,980	13,500	8,260	6,210
28	22,300	3,880	12,187	6,670	5,225	7,015	3,380	22,470	3,580	12,700	7,410	6,670
29	17,700	....	19,620	5,880	9,655	6,900	5,015	17,235	3,520	10,300	6,560	6,490
30	13,820	....	22,470	5,440	6,624	6,555	11,350	22,640	4,180	9,160	6,030	6,210
31	12,565	....	27,500	....	6,166	....	8,670	17,545	....	8,310	....	6,320
1907												
1	12,400	5,880	8,430	7,240	7,830	11,800	6,530	2,750	2,530	4,780	2,210	7,080
2	14,500	6,720	10,000	6,720	7,850	71,300	5,860	2,790	2,210	4,320	2,310	6,320
3	16,900	6,560	11,400	10,400	8,310	45,100	5,770	2,510	2,080	4,240	5,020	5,860
4	14,000	6,490	15,000	9,030	7,640	30,100	4,910	2,860	6,170	3,640	5,750	5,290
5	11,400	6,620	15,200	7,640	7,540	19,300	4,660	2,490	8,500	3,320	4,990	4,700
6	10,700	6,900	11,600	7,080	6,950	17,100	4,410	2,190	4,490	3,130	5,770	4,660
7	9,480	6,620	10,600	12,300	14,500	13,500	4,320	2,490	2,640	2,900	4,660	4,450
8	8,740	6,320	9,400	19,600	12,000	12,400	4,780	2,620	2,670	2,750	4,180	4,240
9	8,120	6,030	8,670	34,400	25,400	11,800	4,000	2,570	2,820	2,940	3,640	4,800
10	7,360	7,240	9,200	40,900	17,800	11,700	4,080	3,070	2,690	2,820	3,840	10,300
11	6,720	8,070	9,660	34,000	14,000	16,200	3,600	4,080	2,750	2,670	4,490	29,300
12	7,020	8,360	10,000	22,300	11,100	13,500	3,640	4,200	3,130	2,860	4,620	26,400
13	6,900	8,670	13,000	17,400	10,800	12,900	3,760	4,600	3,480	2,980	6,300	21,300
14	7,020	8,360	12,700	17,400	9,400	25,800	3,840	4,620	4,240	2,670	6,490	21,300
15	6,780	8,020	17,200	18,200	8,550	52,400	3,760	3,580	3,240	2,880	5,220	22,300
16	8,070	7,780	17,500	11,000	7,950	44,500	3,200	2,920	3,130	2,670	4,660	17,700
17	9,400	7,240	14,600	9,530	10,100	22,300	3,440	2,800	2,750	2,350	4,530	13,800
18	13,600	6,950	12,500	8,840	8,840	16,800	3,440	3,700	2,640	2,570	4,280	13,000
19	17,900	6,850	11,000	8,430	7,830	12,800	3,280	2,860	2,690	2,150	7,180	10,700
20	18,000	6,390	10,700	8,310	7,130	11,100	5,950	2,490	2,570	2,170	7,080	9,680
21	17,100	6,440	10,000	7,830	6,560	9,900	5,660	2,600	2,670	2,280	6,950	8,310
22	14,900	6,390	12,400	7,360	5,770	8,310	4,040	2,670	2,920	2,080	8,310	7,780
23	11,100	5,880	11,900	7,240	5,590	9,030	3,720	2,310	8,310	2,210	10,000	12,600
24	8,980	5,660	10,300	11,600	5,220	9,830	3,280	2,980	61,700	2,170	23,300	39,000
25	7,590	5,290	8,910	10,400	5,220	9,900	3,110	2,880	31,400	2,020	28,200	34,800

Daily discharge, in second-feet, of James River at Cartersville, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	7,480	7,080	8,070	11,400	5,330	8,670	2,940	2,790	14,900	2,070	22,300	25,800
27	6,780	7,310	7,130	11,600	5,510	7,590	2,920	3,320	9,530	2,210	17,400	18,400
28	6,210	7,880	6,950	10,500	5,440	9,780	2,980	3,860	7,270	2,030	12,300	17,500
29	5,550	....	6,490	9,230	4,740	8,070	2,690	3,280	6,390	2,670	10,200	16,200
30	5,590	....	5,880	8,670	4,530	7,480	2,530	2,750	5,900	2,710	7,830	12,300
31	5,880	....	5,880	....	4,800	....	2,860	2,490	....	2,280	....	14,300
1908												
1	14,800	6,800	12,200	12,900	8,080	8,260	3,810	4,500	4,350	3,630	15,200	3,360
2	14,400	7,040	10,500	28,000	7,480	7,210	4,850	3,790	3,870	3,100	10,700	3,550
3	12,200	7,180	10,200	27,000	7,660	6,750	3,950	2,980	3,400	2,540	8,130	3,360
4	10,600	6,870	13,600	22,400	7,410	12,000	4,350	2,610	3,120	2,440	6,890	3,060
5	11,500	6,560	12,800	17,800	7,140	16,800	3,950	2,720	2,910	2,330	5,740	3,230
6	10,600	6,610	17,800	13,600	7,410	12,500	3,750	2,630	19,600	2,130	5,110	3,360
7	10,600	7,040	22,300	11,800	12,000	14,200	4,560	2,450	15,400	2,130	4,810	7,160
8	41,000	6,700	27,300	10,700	19,000	10,200	5,240	2,580	8,700	2,130	4,500	9,240
9	21,100	6,320	22,500	9,700	22,500	8,290	4,850	2,560	5,740	2,100	4,150	6,340
10	15,800	6,220	20,000	8,950	18,500	7,820	4,560	3,850	4,560	2,180	3,830	5,350
11	11,800	6,560	16,500	8,440	13,400	7,480	4,190	3,360	4,030	2,440	3,950	5,850
12	31,800	6,560	14,500	8,000	11,200	7,060	3,790	3,250	3,610	2,370	3,810	6,870
13	54,000	8,570	13,100	7,840	9,950	6,630	2,940	4,350	3,250	2,370	3,750	8,970
14	63,300	14,900	11,800	7,680	8,340	6,530	2,670	3,300	2,910	2,490	3,570	8,080
15	30,900	35,800	10,600	7,540	7,310	6,850	2,650	2,790	2,740	2,670	4,350	8,180
16	22,500	61,900	9,860	7,820	6,440	15,400	2,440	2,510	2,610	2,400	5,240	6,920
17	17,300	64,700	9,570	8,180	5,690	10,100	2,030	2,220	2,490	2,280	4,350	5,970
18	14,500	29,700	9,320	7,280	6,270	9,320	1,940	2,160	2,330	2,130	4,350	5,350
19	12,900	21,800	9,650	7,410	7,710	8,340	1,890	1,890	2,200	1,960	4,010	4,980
20	11,100	21,200	11,400	7,740	9,780	5,690	1,810	2,510	2,060	1,990	4,560	4,770
21	10,100	17,800	12,800	7,310	19,600	5,420	1,810	2,470	2,030	1,960	6,920	4,560
22	9,110	14,800	13,200	6,940	23,500	7,260	1,880	1,940	1,990	1,980	6,870	4,500
23	8,570	13,200	12,300	6,460	19,100	5,580	2,450	1,860	2,060	1,990	6,100	4,810
24	7,640	10,700	13,000	6,270	20,500	6,580	4,560	1,730	2,060	2,560	5,280	4,890
25	7,240	9,890	12,200	5,850	16,600	5,870	4,470	1,930	1,940	6,680	4,850	5,690
26	6,750	18,500	11,600	6,040	13,900	4,850	4,150	39,900	1,940	13,200	4,560	6,100
27	8,730	19,500	10,800	5,970	11,300	4,090	7,310	25,200	1,930	8,260	4,430	7,160
28	8,390	14,400	9,240	6,410	10,100	3,830	10,200	15,900	3,670	6,820	3,990	8,680
29	8,130	13,100	9,000	7,280	10,400	3,550	6,530	11,300	9,810	10,300	3,750	9,890
30	8,730	....	8,310	6,820	9,860	3,830	7,460	7,040	5,510	19,600	3,550	18,600
31	7,360	....	8,620	....	11,600	....	5,580	5,420	....	20,300	....	17,700
1909												
1	22,800	8,700	13,200	10,400	9,320	9,950	5,740	1,990	1,600	1,690	1,820	1,690
2	20,200	7,010	12,000	9,600	12,800	13,600	6,040	5,060	1,530	1,600	1,780	1,660
3	17,200	6,750	10,600	8,650	12,200	12,400	6,150	4,350	1,470	1,440	1,690	1,600
4	13,400	6,630	11,600	8,030	15,300	15,700	5,690	3,170	1,370	1,410	1,730	1,570
5	19,600	6,580	11,500	7,660	10,500	23,400	5,130	2,810	1,380	1,370	1,770	1,600
6	33,700	6,270	11,400	7,310	9,140	19,000	4,730	2,790	1,410	1,410	1,820	1,730
7	28,100	6,040	13,400	6,990	8,230	13,900	5,240	2,920	1,340	1,440	1,730	1,760
8	22,200	5,970	12,800	6,200	7,460	11,300	5,420	2,870	1,410	1,410	1,780	1,860
9	17,100	7,920	12,000	5,830	6,890	10,100	4,980	2,440	1,470	1,410	1,610	1,930
10	18,400	15,900	12,100	5,350	6,460	16,200	5,350	2,470	2,060	1,410	1,660	1,990
11	10,900	23,100	12,200	5,280	7,310	14,500	4,850	2,440	2,940	1,370	1,820	1,890
12	9,660	30,200	11,500	5,350	13,200	14,700	3,830	1,990	2,400	1,760	1,810	1,820
13	8,420	22,400	10,700	5,460	11,500	12,800	3,440	2,030	1,890	4,350	1,760	1,960
14	7,790	17,600	10,100	13,300	9,410	10,100	3,510	1,990	1,630	5,240	1,740	9,410
15	7,710	13,100	9,350	32,700	7,920	9,190	3,250	1,930	1,810	4,150	1,730	12,400
16	8,000	11,900	8,890	47,300	7,060	9,600	3,170	2,160	1,820	3,530	1,710	13,400
17	11,500	11,100	8,570	22,400	6,200	8,650	3,060	2,980	1,930	3,360	1,820	8,030
18	15,400	10,300	7,610	18,900	5,870	11,000	2,910	3,400	2,220	2,370	1,820	6,010
19	17,200	12,700	7,160	13,500	5,150	11,600	2,690	3,100	2,790	2,150	1,860	4,980
20	14,700	18,300	6,970	11,700	4,770	10,100	2,510	2,690	4,680	2,130	1,860	4,070

Daily discharge, in second-feet, of James River at Cartersville, Va., for 1906–1911—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	14,800	17,900	6,680	10,800	6,270	6,100	2,720	2,440	3,830	1,890	1,790	3,510
22	15,300	18,000	7,160	9,680	19,300	5,740	2,510	2,160	3,130	1,930	1,820	3,570
23	18,100	15,400	7,770	9,140	31,400	5,330	2,270	1,960	2,790	1,930	1,810	3,060
24	19,400	17,300	7,820	10,000	21,700	5,040	2,200	1,890	2,440	1,860	1,860	2,510
25	18,200	22,200	10,600	11,300	16,300	4,980	2,160	1,860	2,100	1,890	1,890	1,980
26	17,000	20,000	19,000	11,900	14,200	5,020	2,130	1,760	1,990	1,880	1,860	1,980
27	14,800	19,300	21,800	10,600	17,300	4,980	1,960	1,790	1,690	1,860	1,690	2,260
28	12,300	17,400	19,800	9,300	22,600	5,200	2,300	1,760	1,600	1,760	1,730	2,300
29	10,900	....	15,900	8,260	18,300	5,800	2,850	1,760	1,730	1,760	1,730	2,040
30	10,400	....	13,300	7,660	15,400	6,030	2,400	1,660	1,690	1,770	1,710	1,890
31	9,020	....	11,600	....	10,800	....	2,270	1,570	....	1,760	....	1,760
1910												
1	2,040	5,920	18,300	3,340	7,360	3,270	5,600	2,450	1,820	1,240	1,880	2,040
2	2,380	5,150	21,100	3,130	6,560	3,020	5,030	2,510	2,270	1,310	1,880	1,840
3	3,040	5,310	23,600	3,460	5,990	2,810	4,690	3,010	2,180	1,250	2,130	1,760
4	2,960	6,700	17,800	3,850	5,460	2,700	4,560	2,340	2,320	1,220	2,790	1,710
5	3,100	8,030	14,600	4,010	4,870	2,580	6,880	2,250	3,030	1,120	2,600	1,710
6	2,850	7,280	13,100	3,810	4,680	3,000	5,680	2,130	2,580	1,080	2,270	2,050
7	5,530	6,040	10,400	3,530	4,450	3,150	4,940	1,980	2,640	1,130	2,020	2,310
8	6,770	5,390	9,110	3,510	4,580	3,080	6,880	1,860	2,600	2,230	2,050	2,600
9	10,300	5,530	8,310	3,510	4,470	3,150	9,200	1,720	2,380	5,130	1,910	2,470
10	8,840	5,690	7,540	3,340	4,450	4,250	7,110	1,890	1,840	7,960	1,930	2,310
11	6,700	4,890	6,940	3,130	4,540	6,650	4,940	1,960	1,720	4,000	1,880	2,270
12	6,080	4,830	6,410	3,040	4,170	12,600	7,940	1,670	1,600	3,150	1,770	2,310
13	4,960	4,810	5,850	3,610	4,130	27,300	6,300	1,620	1,640	2,560	1,570	1,880
14	4,450	4,580	5,530	3,910	4,050	36,500	9,030	1,670	1,690	2,160	1,440	1,770
15	4,250	4,560	5,350	4,250	3,850	52,900	7,510	1,890	1,600	2,040	1,760	2,020
16	3,890	5,460	5,240	5,530	3,650	60,100	6,330	2,070	1,670	1,710	1,600	1,980
17	3,530	6,170	4,890	15,900	3,480	65,800	7,220	2,070	1,590	1,550	1,760	2,050
18	3,850	17,400	4,750	26,800	3,610	52,200	9,860	1,930	1,570	1,510	1,740	2,160
19	3,910	28,900	4,470	23,500	3,420	31,000	19,300	1,820	1,400	1,540	1,710	2,230
20	3,850	26,900	4,330	20,100	3,320	21,000	21,100	2,020	1,540	2,950	1,570	2,220
21	5,350	16,700	4,190	14,900	3,290	15,500	20,900	1,890	1,470	3,940	1,600	2,090
22	29,200	14,800	4,130	11,500	3,460	12,100	8,900	2,320	1,400	3,190	1,600	2,000
23	25,000	13,600	4,110	10,000	4,330	8,900	7,460	2,680	1,520	4,980	1,570	1,660
24	18,200	12,000	3,930	9,600	4,250	7,180	7,320	2,040	1,430	3,670	1,710	3,190
25	15,100	11,300	3,690	10,400	5,040	6,950	6,810	1,860	1,380	2,950	1,720	3,390
26	10,100	9,730	3,510	9,110	6,340	6,720	4,400	1,840	1,250	3,050	1,710	3,790
27	8,100	8,840	3,500	8,050	5,990	6,540	4,100	1,930	1,270	2,600	1,510	3,590
28	7,040	7,640	3,460	7,580	4,500	6,510	3,610	1,770	1,280	2,360	1,720	4,060
29	6,700	....	3,340	7,740	4,250	6,400	3,170	1,600	1,220	2,130	1,710	4,120
30	6,560	....	3,500	7,580	3,690	5,990	2,850	1,410	1,070	2,250	1,880	4,250
31	6,410	....	3,320	....	3,320	....	2,700	1,670	....	2,130	....	4,500
1911												
1	6,900	30,300	4,280	10,300	6,440	2,260	1,590	900	17,700	1,260	2,900	4,910
2	18,000	19,000	4,080	10,000	5,990	2,080	1,540	900	11,400	1,180	2,710	4,700
3	22,000	15,000	4,080	8,790	5,770	1,830	1,420	1,140	9,280	1,080	2,530	4,280
4	49,400	11,400	3,880	9,030	5,550	1,830	1,290	1,060	6,670	1,320	2,440	3,680
5	36,700	9,780	3,680	15,900	5,120	2,440	1,390	1,040	5,550	1,540	2,260	3,880
6	23,000	7,590	3,680	32,200	5,120	3,090	1,260	1,020	4,490	1,340	2,260	3,480
7	19,600	7,130	3,880	28,200	4,910	2,710	1,260	1,920	4,700	1,390	3,480	3,280
8	13,000	7,130	5,120	23,300	4,700	2,900	2,900	1,670	2,260	1,360	5,550	3,280
9	8,310	6,900	9,780	22,000	4,700	3,280	5,120	1,670	1,830	1,390	13,800	3,090
10	7,830	8,310	8,790	19,000	4,700	3,280	3,880	1,320	1,830	1,490	9,780	2,900
11	5,990	7,130	10,600	16,500	4,490	3,280	2,260	1,360	1,830	1,830	7,360	2,710
12	5,330	7,830	12,200	14,700	4,280	2,900	2,080	1,290	2,350	1,640	6,440	2,530
13	5,120	9,280	13,800	13,000	4,080	2,440	1,830	1,230	2,170	1,670	5,550	2,710
14	4,910	8,070	11,900	10,800	3,880	2,350	2,440	1,360	2,170	1,830	5,330	2,710
15	4,700	7,130	10,600	10,600	3,680	2,170	2,170	1,340	1,830	1,670	4,910	2,710

Daily discharge, in second-feet, of James River at Cartersville, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
16	4,700	6,210	10,000	11,900	3,280	2,000	2,000	2,900	2,350	1,650	4,910	5,120
17	5,330	5,990	9,530	16,500	3,480	2,000	1,920	2,530	2,530	1,830	5,120	17,100
18	5,120	5,770	8,310	14,700	3,280	1,920	2,170	2,350	1,920	6,900	4,910	10,000
19	4,700	6,440	7,830	12,400	2,900	1,830	1,530	1,510	1,830	15,300	5,120	8,070
20	4,490	5,120	6,900	13,000	2,710	1,830	1,450	1,480	1,830	21,600	5,120	5,990
21	4,280	4,910	7,360	12,200	2,710	1,920	1,480	1,480	2,170	10,300	5,120	5,550
22	4,490	5,770	8,310	11,600	2,530	1,830	1,180	1,230	1,830	9,780	5,550	5,770
23	5,330	5,550	8,310	11,400	2,260	1,750	1,220	900	1,920	8,310	5,120	17,100
24	7,130	5,330	7,830	10,300	2,530	1,640	1,080	960	1,830	7,130	4,910	19,600
25	10,300	4,910	6,670	9,280	2,350	2,170	1,020	930	1,640	5,550	4,700	23,000
26	9,030	4,700	6,440	8,310	2,260	2,900	1,230	1,230	1,370	4,910	4,490	18,000
27	8,070	4,490	7,130	7,590	2,170	2,530	1,040	1,260	1,420	4,280	4,280	17,400
28	6,900	4,280	8,310	7,130	2,170	2,000	1,000	1,290	1,360	3,880	5,120	15,900
29	6,670	....	8,790	6,670	2,080	1,830	1,060	1,510	1,320	3,480	7,830	14,700
30	6,900	....	9,780	6,670	2,000	1,640	1,020	2,000	1,320	3,090	5,990	12,400
31	11,400	....	9,280	....	2,000	....	1,080	3,880	....	2,900	....	12,000
1912												
1	13,300	10,800	18,000	26,100	7,580	5,310	5,750	1,740	980	4,460	1,740	2,090
2	12,400	11,400	13,000	22,300	7,340	5,090	5,530	1,740	965	3,230	1,660	2,180
3	13,300	8,540	11,100	20,900	6,420	4,460	4,250	1,820	905	2,830	1,740	2,090
4	10,800	8,060	9,280	23,700	6,190	4,460	4,460	1,910	890	2,450	1,740	2,450
5	9,030	6,880	8,300	19,600	5,970	4,250	4,250	1,910	920	2,360	1,740	2,830
6	7,110	6,420	8,060	16,500	5,970	3,830	4,040	1,660	965	2,270	1,660	3,230
7	6,880	6,190	8,300	15,000	6,650	4,670	3,630	1,570	950	2,090	1,910	3,430
8	5,970	5,970	9,280	13,000	7,580	4,880	3,230	1,570	1,070	1,820	27,800	3,230
9	5,090	5,090	10,600	11,600	8,060	4,460	3,830	1,470	1,660	1,740	14,700	2,830
10	4,880	4,670	13,000	10,600	6,880	3,430	3,080	1,430	1,540	1,740	13,300	2,640
11	5,090	4,250	10,800	9,530	7,110	3,430	2,880	1,540	1,440	1,660	8,060	2,830
12	5,090	4,460	12,700	8,780	39,700	3,030	3,030	1,570	1,160	1,570	6,190	2,830
13	5,970	4,460	33,700	8,540	72,700	2,640	2,830	1,440	1,080	1,570	4,880	2,830
14	8,060	4,040	29,300	8,780	57,200	2,450	2,830	1,470	1,010	1,820	4,460	2,640
15	12,200	3,830	41,700	8,780	32,200	2,450	2,830	1,440	920	1,910	4,460	2,450
16	12,200	4,040	72,700	8,540	32,200	2,360	3,830	1,440	860	2,000	4,250	2,270
17	12,400	4,250	61,700	8,540	42,500	4,670	3,630	1,910	890	1,910	4,040	2,270
18	12,400	5,090	38,600	8,540	40,100	4,460	2,830	2,270	1,010	1,570	3,430	2,450
19	13,500	7,580	23,700	11,900	27,800	4,250	3,230	2,450	1,660	1,820	3,230	2,450
20	13,500	7,340	18,300	9,280	19,300	4,040	3,830	1,470	3,030	1,820	3,230	3,030
21	13,800	7,820	15,600	8,780	14,700	3,030	3,630	1,380	1,910	1,910	2,640	2,640
22	13,500	20,300	14,400	8,540	12,700	3,030	3,230	1,310	1,740	2,000	2,450	2,270
23	11,900	21,300	13,300	8,540	13,400	3,430	1,910	1,280	1,660	2,090	2,450	1,910
24	8,540	26,100	21,300	8,060	9,530	4,040	1,910	1,280	29,600	2,360	2,270	2,270
25	7,340	21,600	26,100	7,110	8,780	3,430	2,270	1,160	35,500	2,360	2,270	2,450
26	6,420	15,600	31,400	6,650	8,060	3,230	2,450	1,100	12,200	2,180	2,180	2,360
27	6,420	35,200	31,100	6,190	7,340	3,230	2,830	1,010	8,540	2,000	2,270	2,640
28	6,190	26,400	23,700	6,420	6,650	5,970	2,270	935	8,540	1,740	2,270	2,830
29	6,190	24,700	42,500	6,880	5,970	5,310	1,660	995	7,820	1,820	2,270	2,830
30	8,060	....	64,500	7,340	5,750	5,090	1,660	1,020	4,460	1,740	2,090	4,250
31	10,600	....	49,800	....	6,190	....	1,740	1,010	....	1,740	....	8,780
1913												
1	12,200	8,060	8,780	19,300	5,970	33,700	4,880	2,640	1,910	2,090	4,670	4,040
2	16,500	7,340	9,780	13,300	5,310	13,000	4,250	2,360	1,740	2,830	4,460	4,880
3	11,900	6,420	9,280	10,800	5,090	10,600	4,040	2,450	1,740	2,000	3,630	6,650
4	11,100	7,580	8,060	9,530	4,880	11,900	3,830	3,430	2,270	1,820	3,430	7,580
5	10,000	7,340	6,420	8,300	4,670	10,800	6,420	3,030	2,090	1,740	3,230	8,540
6	9,780	5,970	5,750	7,820	4,460	10,600	8,780	2,640	2,000	1,660	3,030	7,580
7	8,540	5,750	5,310	7,110	4,250	8,780	6,420	3,630	1,820	1,660	2,830	7,110
8	7,110	5,530	4,880	6,650	4,250	17,100	4,250	2,090	1,740	1,570	2,830	5,970
9	6,650	5,530	4,670	5,970	4,250	9,780	3,830	2,000	1,570	1,820	5,530	5,750
10	9,780	5,310	4,250	5,750	4,040	8,060	3,430	2,640	1,380	2,090	38,600	5,750

Daily discharge, in second-feet, of James River at Cartersville, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	9,030	7,580	5,750	5,310	4,040	6,420	6,650	4,040	1,490	3,430	26,400	5,530
12	8,060	5,090	6,880	11,100	3,830	5,970	3,630	3,830	1,430	2,830	16,500	5,310
13	7,110	4,670	9,780	57,200	3,630	5,530	4,040	2,450	1,410	2,450	13,800	5,090
14	6,650	4,250	34,800	48,600	3,630	5,090	5,090	4,880	1,440	2,640	8,300	4,880
15	5,530	4,040	64,900	39,000	3,430	4,880	3,830	5,090	1,470	2,640	7,340	4,460
16	5,310	3,830	61,200	36,700	3,430	4,460	3,830	4,880	1,380	2,540	5,970	4,250
17	4,880	3,630	42,100	34,400	3,830	3,830	3,430	3,830	1,220	2,270	10,600	4,250
18	4,880	3,230	26,100	24,700	4,670	3,430	3,030	3,230	1,440	2,180	10,800	4,040
19	4,670	3,230	18,300	19,600	4,460	3,230	3,230	3,030	1,570	2,090	10,300	3,830
20	4,250	3,430	14,400	16,800	3,630	3,230	3,030	10,600	1,660	2,830	9,280	3,630
21	4,040	3,430	12,400	13,500	3,630	3,030	3,280	6,190	1,740	4,460	7,820	3,430
22	3,830	3,430	11,600	11,100	3,830	3,030	3,530	5,530	5,750	4,250	7,580	3,430
23	3,830	3,230	10,600	10,000	5,310	4,250	3,780	4,040	5,530	4,040	7,110	3,430
24	3,830	3,230	8,540	8,780	49,800	7,820	4,040	4,460	4,460	5,310	5,530	5,310
25	4,250	3,030	7,820	8,060	47,800	8,540	4,040	5,750	2,830	10,800	5,090	6,190
26	4,040	3,230	7,340	7,580	32,900	7,820	3,230	3,430	2,640	12,400	4,460	13,300
27	4,250	3,430	7,820	7,110	25,000	5,970	3,030	3,230	2,270	10,000	4,250	13,000
28	9,780	5,310	28,900	6,880	26,400	5,750	2,450	3,030	2,000	9,780	4,250	12,700
29	10,000	....	74,600	6,420	20,600	8,060	2,270	2,640	1,820	9,280	4,460	11,600
30	11,900	....	36,700	6,190	21,600	7,340	2,640	2,270	1,740	9,280	4,250	9,280
31	9,530	....	22,600	....	29,300	....	2,090	2,090	....	5,310	....	8,060
1914												
1	5,750	26,100	11,400	10,600	10,300	2,450	2,000	1,510	1,910	980	1,740	2,270
2	6,190	32,200	11,100	10,000	8,060	2,450	1,740	1,470	1,600	830	1,660	2,640
3	6,650	23,700	9,280	9,780	7,580	2,640	2,270	1,540	1,300	815	1,660	9,030
4	27,800	16,500	9,280	9,530	7,340	2,360	2,000	1,490	1,250	890	1,660	8,300
5	24,400	13,800	9,280	9,530	6,880	2,360	3,030	1,510	1,220	1,080	1,540	7,340
6	15,900	12,400	9,280	9,280	7,110	2,360	4,040	1,570	1,130	1,470	1,510	22,000
7	12,200	17,700	9,780	9,030	6,880	2,360	4,040	1,510	1,100	1,570	1,430	32,200
8	11,400	19,000	9,780	8,540	7,110	2,360	3,230	1,280	1,040	1,510	1,430	20,000
9	9,030	24,000	10,000	8,780	7,340	2,270	3,030	1,330	995	1,300	1,490	13,800
10	8,540	19,000	9,280	8,060	6,650	2,450	2,640	1,120	950	1,740	1,570	10,800
11	9,030	14,100	9,280	7,580	6,190	2,360	2,180	1,070	920	1,570	1,570	9,280
12	12,200	13,000	9,530	7,340	5,970	2,270	2,180	1,250	1,040	1,510	1,740	8,540
13	12,700	13,000	9,780	7,110	5,970	2,180	2,450	1,510	1,130	1,470	1,540	7,820
14	11,100	9,280	10,800	6,880	5,750	2,270	2,830	1,460	1,130	1,470	1,510	9,280
15	8,540	8,780	10,300	7,340	5,530	2,180	3,030	1,660	995	3,630	2,640	8,300
16	7,580	8,540	11,100	14,700	4,880	2,270	4,460	1,440	950	4,670	11,900	6,420
17	7,110	7,820	11,400	13,800	4,460	2,180	4,250	1,380	1,020	13,500	8,300	5,310
18	6,420	8,300	14,100	15,300	4,250	2,270	4,040	1,120	1,070	9,780	6,190	4,880
19	6,420	11,400	25,400	14,100	4,040	2,270	3,630	1,040	1,040	8,060	4,670	4,880
20	5,970	23,000	24,000	11,600	4,040	1,660	2,830	1,160	1,010	4,460	4,040	7,340
21	5,750	30,000	18,000	11,400	3,830	1,570	2,450	1,040	1,190	4,040	3,430	11,100
22	5,310	25,400	16,200	11,600	3,830	3,830	1,820	1,040	1,280	2,830	3,030	16,200
23	5,750	20,600	14,100	11,600	3,630	2,180	1,660	1,190	1,220	2,270	2,450	16,500
24	6,420	18,600	13,500	10,300	3,430	2,000	1,520	1,470	1,160	2,180	2,450	15,600
25	18,000	15,900	13,300	9,030	3,230	1,820	1,570	1,510	1,190	2,180	2,270	11,400
26	12,700	15,600	10,800	9,030	3,030	2,270	1,520	1,310	1,190	2,090	2,180	10,600
27	17,100	13,800	10,300	10,300	3,230	2,640	1,520	2,090	1,180	2,090	2,090	8,780
28	12,200	11,900	9,780	12,400	3,030	3,030	1,390	2,450	1,220	1,740	2,000	6,650
29	10,800	....	9,530	14,700	2,640	3,230	1,360	2,360	1,160	1,740	2,090	7,110
30	9,030	....	9,280	11,400	2,640	2,270	1,520	2,180	1,020	1,740	2,000	9,280
31	10,600	....	8,540	....	2,450	....	1,660	2,000	....	1,740	....	13,000

Monthly discharge of James River at Cartersville, Va., for 1899–1914.

[Drainage area, 6,230 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1899						
January	64,000	6,486	13,550	2.17	2.50	
February	49,850	5,990	22,400	3.59	3.74	
March	93,750	10,960	28,610	4.59	5.29	
April	24,180	5,660	9,753	1.56	1.74	
May	16,770	3,580	7,304	1.17	1.35	
June	6,601	2,350	3,799	.610	.681	
July	4,080	1,200	2,030	.326	.376	
August	15,860	1,140	3,227	.518	.598	
September	11,350	1,432	3,187	.511	.570	
October	3,580	1,622	1,968	.316	.364	
November	11,080	2,000	3,566	.572	.638	
December	5,880	1,670	3,020	.485	.559	
The year	93,750	1,140	8,534	1.37	18.40	
1900						
January	36,970	1,060	8,929	1.43	1.65	
February	33,670	2,530	12,590	2.02	2.10	
March	47,160	6,440	14,810	2.38	2.74	
April	29,800	4,490	10,560	1.69	1.89	
May	8,790	3,380	5,096	.818	.943	
June	27,850	2,805	8,072	1.30	1.45	
July	5,120	1,782	2,828	.454	.523	
August	2,995	1,095	1,599	.257	.296	
September	9,280	842	2,498	.401	.447	
October	28,690	1,417	3,860	.619	.713	
November	57,200	2,084	7,109	1.14	1.27	
December	29,980	3,480	8,348	1.34	1.54	
The year	57,200	842	7,192	1.15	15.56	
1901						
January	43,380	2,900	8,770	1.41	1.63	
February	4,910	2,805	3,852	.618	.644	
March	29,260	2,530	8,241	1.32	1.52	
April	71,580	7,015	24,870	3.99	4.45	
May	92,200	5,267	18,630	2.99	3.45	
June	56,400	7,475	17,010	2.73	3.05	
July	16,770	3,147	7,858	1.26	1.45	
August	49,850	2,620	16,670	2.67	3.08	
September	25,750	3,480	6,972	1.12	1.25	
October	12,160	2,440	3,887	.624	.719	
November	9,530	2,170	2,946	.473	.528	
December	97,800	2,710	17,740	2.85	3.29	
The year	97,800	2,170	11,450	1.84	25.06	
1902						
January	50,690	4,952	12,860	2.06	2.38	
February	76,040	4,700	17,130	2.75	2.86	
March	82,290	7,590	22,830	3.66	4.22	
April	28,550	5,330	10,930	1.75	1.95	
May	6,670	3,280	5,578	.895	1.03	
June	41,900	2,000	4,425	.710	.792	
July	3,480	1,125	2,197	.353	.407	
August	8,430	1,125	2,488	.399	.460	
September	8,670	900	1,647	.264	.294	
October	52,180	1,670	7,328	1.18	1.36	
November	23,490	2,000	5,004	.802	.895	
December	30,710	5,660	12,940	2.08	2.40	
The year	82,290	900	8,780	1.41	19.05	

Monthly discharge of James River at Cartersville, Va., for 1899–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1903						
January	48,810	5,120	14,890	2.39	2.76	
February	54,550	10,300	19,550	3.14	3.27	
March	60,340	9,780	23,260	3.73	4.30	
April	30,520	9,730	16,920	2.71	3.02	
May	11,080	4,040	6,367	1.02	1.18	
June	57,200	4,080	13,240	2.12	2.36	
July	15,320	2,404	6,063	.973	1.12	
August	33,480	2,404	5,396	.866	.998	
September	20,440	2,548	5,910	.948	1.06	
October	8,550	2,170	2,976	.478	.551	
November	3,128	2,051	2,443	.392	.437	
December	4,868	1,915	2,506	.402	.463	
The year	60,340	1,915	9,960	1.60	21.52	
1904						
January	11,890	2,085	3,660	.587	.677	
February	13,790	3,090	6,332	1.02	1.10	
March	36,670	5,225	10,060	1.61	1.86	
April	24,350	3,480	6,777	1.09	1.22	
May	27,680	5,594	9,334	1.50	1.73	
June	25,750	2,805	6,927	1.11	1.24	
July	4,595	1,670	2,935	.471	.543	
August	6,371	1,125	2,900	.465	.536	
September	7,360	1,170	1,828	.293	.327	
October	1,386	900	1,115	.179	.206	
November	2,440	1,125	1,470	.236	.263	
December	4,490	1,432	2,724	.437	.504	
The year	36,670	900	4,672	.750	10.21	
1905						
January	13,960	2,440	5,439	.873	1.01	
February	14,540	3,128	6,378	1.02	1.06	
March	33,300	6,394	11,900	1.91	2.20	
April	9,330	3,320	5,643	.905	1.01	
May	32,560	2,805	9,388	1.51	1.74	
June	16,770	2,085	5,309	.852	.951	
July	50,230	3,680	13,490	2.16	2.49	
August	20,940	2,957	6,086	.977	1.13	
September	17,700	1,864	4,024	.646	.721	
October	4,658	1,590	2,227	.357	.412	
November	2,530	1,702	1,967	.316	.353	
December	36,290	1,830	9,017	1.45	1.67	
The year	50,230	1,590	6,739	1.08	14.75	
1906						
January	52,800	6,170	13,800	2.22	2.56	
February	11,300	3,480	5,380	.863	.90	
March	27,500	3,920	12,700	2.04	2.35	
April	25,800	5,440	11,600	1.86	2.08	
May	9,660	3,000	4,910	.789	.91	
June	16,000	2,710	5,850	.939	1.05	
July	11,400	2,170	4,020	.645	.74	
August	23,400	2,900	10,600	1.70	1.96	
September	13,100	3,480	5,110	.820	.91	
October	84,800	5,160	20,800	3.34	3.85	
November	28,600	4,450	9,230	1.48	1.65	
December	19,600	3,880	6,750	1.08	1.24	
The year	84,800	2,170	9,230	1.48	20.20	

Monthly discharge of James River at Cartersville, Va., for 1899–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1907						
January	18,000	5,550	10,100	1.62	1.87	A.
February	8,670	5,290	6,930	1.11	1.16	A.
March	17,500	5,880	10,700	1.72	1.98	A.
April	40,900	6,720	13,600	2.18	2.43	B.
May	25,400	4,530	8,720	1.40	1.61	B.
June	71,300	7,480	18,700	3.00	3.35	B.
July	6,530	2,530	4,000	.642	.74	A.
August	4,620	2,190	3,040	.488	.56	A.
September	61,700	2,080	7,280	1.17	1.30	B.
October	4,780	2,020	2,760	.443	.51	A.
November	28,200	2,210	8,130	1.30	1.45	B.
December	39,000	4,240	14,500	2.33	2.69	B.
The year	71,300	2,020	9,040	1.45	19.65	
1908						
January	63,300	6,750	16,900	2.71	3.12	B.
February	64,700	6,220	16,100	2.58	2.78	B.
March	27,300	8,310	13,100	2.10	2.42	B.
April	28,000	5,850	10,200	1.64	1.83	B.
May	23,500	5,690	11,900	1.91	2.20	A.
June	16,800	3,550	7,940	1.27	1.42	A.
July	10,200	1,810	4,080	.655	.76	A.
August	39,900	1,730	5,600	.899	1.04	A.
September	19,600	1,930	4,430	.711	.79	A.
October	20,300	1,960	4,560	.732	.84	A.
November	15,200	3,550	5,380	.864	.96	A.
December	17,700	3,060	6,480	1.04	1.20	A.
The year	64,700	1,730	8,890	1.43	19.36	
1909						
January	33,700	7,710	15,500	2.49	2.87	B.
February	30,200	5,970	14,000	2.25	2.34	B.
March	21,800	6,680	11,500	1.85	2.13	A.
April	47,300	5,290	11,700	1.88	2.10	B.
May	31,400	4,770	11,900	1.91	2.20	B.
June	23,400	4,980	10,400	1.67	1.86	A.
July	6,150	1,960	3,660	.587	.68	A.
August	5,060	1,570	2,460	.395	.46	A.
September	4,680	1,330	2,070	.332	.37	A.
October	5,240	1,370	2,110	.339	.39	A.
November	1,890	1,610	1,770	.284	.32	A.
December	13,400	1,570	3,490	.560	.65	B.
The year	47,300	1,330	7,550	1.21	16.37	
1910						
January	29,200	2,040	7,450	1.20	1.38	A.
February	28,900	4,560	9,430	1.51	1.57	A.
March	23,600	3,320	7,690	1.23	1.42	A.
April	26,800	3,040	8,060	1.29	1.44	A.
May	7,360	3,290	4,500	.722	.83	A.
June	65,800	2,580	16,000	2.57	2.87	B.
July	21,100	2,700	7,490	1.20	1.38	A.
August	3,010	1,410	2,000	.321	.37	A.
September	3,030	1,070	1,770	.284	.32	A.
October	7,960	1,080	2,580	.414	.48	A.
November	2,790	1,440	1,830	.294	.33	A.
December	4,500	1,660	2,530	.406	.47	A.
The year	65,800	1,070	5,900	.947	12.86	

Monthly discharge of James River at Cartersville, Va., for 1899–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1911						
January	49,400	4,280	10,800	1.73	1.99	A.
February	30,300	4,280	8,270	1.33	1.38	A.
March	13,800	3,680	7,780	1.25	1.44	A.
April	32,200	6,670	13,500	2.17	2.42	A.
May	6,440	2,000	3,680	.591	.68	A.
June	3,280	1,640	2,290	.368	.41	A.
July	5,120	1,000	1,740	.279	.32	A.
August	3,880	900	1,510	.242	.28	A.
September	17,700	1,320	3,420	.549	.61	A.
October	21,600	1,080	4,290	.689	.79	A.
November	13,800	2,260	5,190	.833	.93	A.
December	23,000	2,530	8,340	1.34	1.54	A.
The year	49,400	900	5,880	.944	12.79	
1912						
January	13,800	4,880	9,290	1.49	1.72	A.
February	35,200	3,830	11,100	1.78	1.92	B.
March	72,700	8,060	25,300	4.06	4.68	C.
April	26,100	6,190	11,500	1.85	2.06	B.
May	72,700	5,750	17,400	2.79	3.22	C.
June	5,970	2,360	3,950	.634	.71	A.
July	5,750	1,660	3,200	.514	.59	A.
August	2,450	935	1,490	.239	.28	A.
September	35,500	860	4,530	.727	.81	B.
October	4,460	1,570	2,080	.334	.39	A.
November	27,800	1,660	4,580	.735	.82	B.
December	8,780	1,910	2,850	.457	.53	A.
The year	72,700	860	8,110	1.30	17.73	
1913						
January	16,500	3,830	7,520	1.21	1.40	A.
February	8,060	3,030	4,860	.780	.81	A.
March	74,600	4,250	18,700	3.00	3.46	B.
April	57,200	5,310	15,800	2.54	2.83	B.
May	49,800	3,430	11,400	1.83	2.11	B.
June	33,700	3,030	8,070	1.30	1.45	A.
July	8,780	2,090	4,010	.644	.74	A.
August	10,600	2,000	3,720	.597	.69	A.
September	5,750	1,220	2,120	.340	.38	A.
October	12,400	1,570	4,200	.674	.78	A.
November	38,600	2,830	8,210	1.32	1.47	A.
December	13,300	3,430	6,410	1.03	1.19	A.
The year	74,600	1,220	7,930	1.27	17.31	
1914						
January	27,800	5,310	10,600	1.70	1.96	A.
February	32,200	7,820	16,900	2.71	2.82	B.
March	25,400	8,540	11,900	1.91	2.20	A.
April	15,300	6,880	10,400	1.67	1.86	A.
May	10,300	2,450	5,200	.835	.96	A.
June	3,830	1,570	2,360	.379	.42	B.
July	4,460	1,360	2,510	.403	.46	B.
August	2,450	1,040	1,490	.239	.28	B.
September	1,910	920	1,160	.186	.21	B.
October	13,500	815	2,800	.449	.52	B.
November	11,900	1,430	2,790	.448	.50	B.
December	32,200	2,270	10,500	1.69	1.95	A.
The year	32,200	815	6,490	1.04	14.14	

NOTE.—Ice present but no corrections were applied to the computed discharge estimates for following periods: Dec. 30, 1899, to Jan. 12, 1900; Dec. 21-24, 1901; part of January, 1904; Dec. 21-23, 1904; latter part of January and during February, 1905; Dec. 7-16 and 18-21, 1910. The computed daily discharge Dec. 24-31, 1909, was reduced 10 per cent because of probable effect of ice.

COWPASTURE RIVER NEAR CLIFTON FORGE, VA.

Location.—At the iron highway bridge, 1½ miles above junction with Jackson River, and about 4 miles southeast of Clifton Forge.

Drainage area.—460 square miles.

Records available.—May 13, 1907, to August 8, 1908.

Gage.—Vertical staff on first pier from left bank.

Discharge measurements.—Made from the bridge.

Channel and control.—Banks may overflow, but all water will pass beneath the bridge. Bed is composed of rock.

Extremes of discharge.—Maximum stage recorded: 10.0 feet, June 14, 1907; discharge not computed. Minimum stage recorded: 1.0 foot, September and October, 1907; discharge, 148 second-feet.

Winter flow.—Discharge relation not affected by ice during winter of 1907-8.

Accuracy.—Results fair for low and medium stages. Rating curve not developed for high stages. Gage readings poor.

Coöperation.—Station maintained by United States Geological Survey in coöperation with the United States Forest Service.

Discharge measurements of Cowpasture River near Clifton Forge, Va., in 1907.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
May 13....	R. J. Taylor.......	2.00	671	July 18...	R. G. Knight........	1.39	317
June 27....	R. G. Knight.......	1.89	608	July 25...	.....do	1.21	210

Daily gage height, in feet, of Cowpasture River near Clifton Forge, Va., for 1907–8.

[Florence Persinger, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	2.0	1.7	1.2	1.0	1.0	1.0	3.7
2	......	......	......	......	......	7.0	1.6	1.0	1.0	1.0	1.0	3.3
3	......	......	......	......	......	3.7	1.5	1.0	1.0	1.0	3.0	3.0
4	......	......	......	......	......	2.9	1.4	1.0	1.0	1.0	2.3	2.8
5	......	......	......	......	......	2.7	1.4	1.0	1.5	1.0	2.0	2.6
6	......	......	......	......	......	2.7	1.4	1.0	1.8	1.0	2.0	2.4
7	......	......	......	......	......	2.5	1.4	1.0	1.2	1.0	1.8	2.0
8	......	......	......	......	......	2.4	1.3	1.0	1.0	1.0	1.7	1.7
9	......	......	......	......	......	4.0	1.3	1.0	1.0	1.0	1.5	1.6
10	......	......	......	......	......	3.2	1.3	2.0	1.0	1.0	2.4	6.0
11	......	......	......	......	......	3.0	1.3	1.6	1.3	1.0	2.3	4.7
12	......	......	......	......	......	3.4	1.3	1.4	1.2	1.0	2.2	4.5
13	......	......	......	......	2.0	5.0	1.3	1.3	1.2	1.0	2.0	4.0
14	......	......	......	......	1.9	10.0	1.3	1.3	1.2	1.0	1.8	3.6
15	......	......	......	......	1.8	5.0	1.2	1.2	1.0	1.0	1.7	3.0
16	......	......	......	......	1.8	3.4	1.2	1.2	1.0	1.0	1.7	2.7
17	......	......	......	......	1.7	3.0	1.2	1.2	1.0	1.0	1.5	2.5
18	......	......	......	......	1.7	2.5	1.4	1.2	1.0	1.0	1.4	2.3
19	......	......	......	......	1.6	2.3	1.8	1.2	1.0	1.0	2.0	2.0
20	......	......	......	......	1.6	2.1	1.7	1.2	1.0	1.0	1.8	2.9
21	......	......	......	......	1.6	1.9	1.5	1.2	1.0	1.0	1.7	2.8
22	......	......	......	......	1.5	2.0	1.4	1.2	1.0	1.0	2.0	7.0
23	......	......	......	......	1.5	2.0	1.3	1.2	6.5	1.0	2.0	6.0
24	......	......	......	......	1.4	2.0	1.3	1.8	4.0	1.0	5.5	5.6
25	......	......	......	......	1.4	2.0	1.2	1.8	3.5	1.0	5.4	5.0
26	......	......	......	......	1.5	2.0	1.2	1.6	2.3	1.0	5.0	4.0
27	......	......	......	......	1.4	1.9	1.2	1.5	2.2	1.0	4.7	3.5
28	......	......	......	......	1.4	1.9	1.2	1.4	1.2	1.0	4.6	3.0
29	......	......	......	......	1.4	1.8	1.2	1.3	1.0	1.0	4.4	5.0
30	......	......	......	......	1.4	1.7	1.2	1.2	1.0	1.0	4.0	4.6
31	......	......	......	......	1.4	......	1.2	1.2	......	1.0	......	4.3
1908												
1	4.0	1.0	2.0	6.3	2.0	2.1	1.8	1.5	......	......	......	......
2	3.6	1.0	2.0	6.0	2.4	2.0	1.3	1.4	......	......	......	......
3	3.3	1.0	4.0	5.4	2.2	2.0	1.3	1.4	......	......	......	......
4	3.0	1.0	4.0	4.0	2.0	2.0	1.5	1.2	......	......	......	......
5	2.6	1.0	3.7	3.5	2.0	2.0	1.6	1.1	......	......	......	......
6	2.3	1.0	6.5	3.0	2.0	1.9	1.8	1.1	......	......	......	......
7	2.2	1.0	5.5	2.8	5.0	1.9	1.8	1.1	......	......	......	......
8	2.0	1.0	5.0	2.2	7.0	1.8	1.7	1.1	......	......	......	......
9	1.8	1.0	4.6	1.5	4.0	1.9	1.5	......	......	......	......	......
10	1.6	1.0	4.3	1.2	3.6	2.0	1.3	......	......	......	......	......
11	1.5	1.0	4.0	1.0	3.4	2.0	1.3	......	......	......	......	......
12	9.0	1.0	3.5	2.0	3.0	2.0	1.2	......	......	......	......	......
13	7.0	1.0	3.0	2.0	2.4	2.0	1.2	......	......	......	......	......
14	6.0	4.0	2.4	1.9	2.0	2.0	1.2	......	......	......	......	......
15	4.0	4.0	2.0	1.6	2.0	2.2	1.1	......	......	......	......	......
16	3.6	7.0	1.7	1.6	2.0	2.3	1.1	......	......	......	......	......
17	3.3	5.3	1.4	1.4	3.3	2.2	1.1	......	......	......	......	......
18	3.0	5.0	1.2	1.2	3.3	2.0	1.1	......	......	......	......	......
19	2.6	4.5	2.3	1.0	3.2	2.0	1.1	......	......	......	......	......
20	2.3	4.0	2.3	1.0	5.0	1.9	1.1	......	......	......	......	......
21	2.0	3.4	2.2	1.0	3.0	1.8	1.1	......	......	......	......	......
22	1.7	3.0	2.0	1.85	3.3	1.7	1.1	......	......	......	......	......
23	1.4	3.0	2.0	1.8	4.0	1.5	1.1	......	......	......	......	......
24	1.3	2.8	1.8	1.8	3.7	1.5	1.1	......	......	......	......	......
25	1.0	2.6	1.6	1.8	3.0	1.5	1.1	......	......	......	......	......

Daily gage height, in feet, of Cowpasture River near Clifton Forge, Va., for 1907–8—
Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
26	1.0	2.5	1.5	1.7	2.7	1.5	1.1	......	......	......	......	......
27	1.0	2.5	1.3	1.7	2.5	1.5	1.1	......	......	......	......	......
28	1.0	2.4	1.8	1.6	2.3	1.4	1.3	......	......	......	......	......
29	1.0	2.3	1.2	1.6	2.1	1.4	2.3	......	......	......	......	......
30	1.0	......	1.0	1.6	2.1	1.4	2.0	......	......	......	......	......
31	1.0	......	5.5	......	2.1	......	1.8	......	......	......	......	......

Daily discharge, in second-feet, of Cowpasture River near Clifton Forge., Va., for 1907–8.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	674	472	221	148	148	148	......
2	......	......	......	......	......	......	414	148	148	148	148	......
3	......	......	......	......	......	......	360	148	148	148	......	......
4	......	......	......	......	......	......	310	148	148	148	915	......
5	......	......	......	......	......	......	310	148	360	148	674	......
6	......	......	......	......	......	......	310	148	264	148	674	1,000
7	......	......	......	......	......	1,100	310	148	221	148	534	674
8	......	......	......	......	......	1,000	264	148	148	148	472	472
9	......	......	......	......	......	......	264	148	148	148	360	414
10	......	......	......	......	......	......	264	674	148	148	1,000	......
11	......	......	......	......	......	......	264	414	264	148	915	......
12	......	......	......	......	......	......	264	310	221	148	830	......
13	......	......	......	......	674	......	264	264	221	148	674	......
14	......	......	......	......	601	......	264	264	221	148	534	......
15	......	......	......	......	534	......	221	221	148	148	472	......
16	......	......	......	......	534	......	221	221	148	148	472	......
17	......	......	......	......	472	......	221	221	148	148	360	1,100
18	......	......	......	......	472	1,100	310	221	148	148	310	915
19	......	......	......	......	414	915	534	221	148	148	674	674
20	......	......	......	......	414	750	472	221	148	148	534	......
21	......	......	......	......	414	601	360	221	148	148	472	......
22	......	......	......	......	360	674	310	221	148	148	674	......
23	......	......	......	......	360	674	264	221	......	148	674	......
24	......	......	......	......	310	674	264	264	......	148	......	......
25	......	......	......	......	310	674	221	534	......	148	......	......
26	......	......	......	......	360	674	221	414	915	148	......	......
27	......	......	......	......	310	601	221	360	830	148	......	......
28	......	......	......	......	310	601	221	310	221	148	......	......
29	......	......	......	......	310	534	221	264	148	148	......	......
30	......	......	......	......	310	472	221	221	148	148	......	......
31	......	......	......	......	310	......	221	221	......	148	......	......
1908												
1	......	148	674	......	674	750	264	360	......	......	......	......
2	......	148	674	......	1,000	674	264	310	......	......	......	......
3	......	148	......	......	830	674	264	310	......	......	......	......
4	......	148	......	......	674	674	360	221	......	......	......	......
5	......	148	......	......	674	674	414	182	......	......	......	......

Daily discharge, in second-feet, of Cowpasture River near Clifton Forge, Va., for 1907–8—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
6	915	148	....	....	674	601	534	182	....	....	....	....
7	830	148	....	....	....	601	534	182	....	....	....	....
8	674	148	....	830	....	534	472	182	....	....	....	....
9	534	148	....	360	....	601	360	....	....	....	....	....
10	414	148	....	221	....	674	264	....	....	....	....	....
11	360	148	....	148	....	674	264	....	....	....	....	....
12	....	148	....	674	....	674	221	....	....	....	....	....
13	....	148	....	674	1,000	674	221	....	....	....	....	....
14	....	....	1,000	601	674	674	221	....	....	....	....	....
15	....	....	674	414	674	830	182	....	....	....	....	....
16	....	....	472	414	674	915	182	....	....	....	....	....
17	....	....	310	310	....	830	182	....	....	....	....	....
18	....	....	221	221	....	674	182	....	....	....	....	....
19	....	....	915	148	....	674	182	....	....	....	....	....
20	915	....	915	148	....	601	182	....	....	....	....	....
21	674	....	830	148	....	534	182	....	....	....	....	....
22	472	....	674	568	....	472	182	....	....	....	....	....
23	310	....	674	534	....	360	182	....	....	....	....	....
24	264	....	534	534	....	360	182	....	....	....	....	....
25	148	....	414	534	....	360	182	....	....	....	....	....
26	148	1,100	360	472	....	360	182	....	....	....	....	....
27	148	1,100	264	472	1,100	360	182	....	....	....	....	....
28	148	1,000	264	414	915	310	264	....	....	....	....	....
29	148	915	221	414	750	310	915	....	....	....	....	....
30	148	....	148	414	750	310	674	....	....	....	....	....
31	148	....	....	....	750	....	534	....	....	....	....	....

NOTE.—Daily discharges for 1907 and 1908 are based on a well-defined rating curve. The discharge was greater than 1,200 second-feet for all missing days from May 13, 1907, to August 8, 1908.

ROANOKE RIVER BASIN.

ROANOKE RIVER AT ROANOKE, VA.

Location.—At Walnut Street highway bridge in Roanoke.

Drainage area.—388 square miles.

Records available.—July 10, 1896, to July 15, 1906; May 7, 1907, to December 31, 1914.

Gage.—Chain on downstream side of Walnut Street bridge; read once daily. Wire gage used previous to November 28, 1903.

Discharge measurements.—Made from downstream side of Walnut Street bridge or from Jefferson Street bridge about one-third mile above. Measurement of overflow from Crystal Spring, which enters river between the two bridges, added when discharge measurements are made at Jefferson Street bridge.

Channel and control.—Bed composed of coarse gravel and small bowlders. Both banks may overflow at extreme flood stages. Control, loose bowlders; shifts slightly.

Extremes of discharge.—Maximum stage recorded: 14.34 feet, August 6, 1901; discharge, 16,860 second-feet. Minimum stage recorded, 0.0 on morning of December 23, 1909, when flow was retarded by freezing; reported that practically no water was flowing.

Winter flow.—Ice seldom forms at station, but flow is sometimes retarded by freezing of headwaters.

Accuracy.—Frequent measurements necessary to adequately define rating curve at low stages. Rating curves at high stages not well defined, and estimates of discharge only fair except for periods during which frequent measurements were made.

Coöperation.—Records collected in coöperation by United States Geological Survey and Roanoke Railway & Electric Co., J. W. Hancock, general manager.

Discharge measurements of Roanoke River at Roanoke, Va., for 1906–1915.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
1906			
June 10....	Robert Follansbee..	0.76	119
1907			
May 7.....	R. J. Taylor.......	2.65	1330
June 22....	R. G. Knight.......	1.48	490
July 20....	.....do	1.12	319
July 24....	.....do	.88	187
1909			
July 22....	G. C. Stevens......	.90	136
July 23....	.....do	1.00[a]	151[b]
Sept. 10...	Stevens and Thomas	1.29	274
1910			
Sept. 6....	G. C. Stevens......	1.24	278

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
1911			
July 27...	J. G. Mathers......	0.68	82.5
July 27...	Mathers and Dean..	.69	79.8
July 28...	.....do	.71	88.9
1912			
Nov. 22..	Jackson and Batchelder	.88	132
Nov. 22..	.....do	.86	131
1914			
Oct. 3....	J. G. Mathers.......	.60	62.5
Oct. 3....	.....do	.62	71.8
1915			
June 24...	H. J. Dean..........	.88	144

[a] Staff gage at Jefferson Street Bridge.
[b] Includes 1.5 second-feet from Crystal Spring.

Daily gage height, in feet, of Roanoke River at Roanoke, Va., for 1906–1914.

[C. C. Hogshead, W. J. Lambert, and M. A. Turner, observers.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	1.35	1.8	1.0	2.3	1.85	1.1	0.8
2	1.3	1.7	1.1	2.05	1.3	1.0	.8
3	4.8	1.6	1.15	1.75	1.3	.9	.75
4	3.6	1.5	1.7	1.65	1.2	.7	.75
5	2.8	1.5	1.5	1.55	1.1	.8	.7
6	2.15	1.5	1.4	1.5	1.2	.8	.7
7	1.85	1.4	1.3	1.45	1.3	.8	.7
8	1.75	1.4	1.3	1.4	1.3	.8	.7
9	1.65	1.35	1.3	1.4	1.3	.7	.7
10	1.5	1.3	1.2	1.7	1.1	.8	.7
11	1.5	1.2	1.2	1.6	1.1	.8	.7
12	1.5	1.2	1.2	1.55	1.1	.8	.65
13	1.4	1.2	1.2	1.4	1.0	1.4	.65
14	1.4	1.2	1.15	1.4	1.0	1.3	.65
15	1.5	1.2	1.4	1.8	.9	1.2	.7
16	1.5	1.2	1.5	2.0	1.0	1.1	....
17	1.5	1.2	2.0	1.85	1.0	1.0	....
18	1.45	1.1	2.1	1.7	1.0	1.0	....
19	1.4	1.1	2.2	1.6	1.0	.9	....
20	1.35	1.1	2.2	1.5	.9	.8	....
21	1.3	1.1	2.2	1.4	1.4	1.1	....
22	1.3	1.05	2.1	1.6	1.3	1.0	....
23	4.05	1.05	2.0	1.5	1.4	.9	....
24	2.7	1.05	1.8	1.4	1.4	.8	....
25	2.2	1.05	1.7	1.3	1.2	.8	....
26	2.05	1.05	1.6	1.3	1.1	.8	....
27	1.85	1.1	2.15	1.2	1.0	.8	....
28	1.3	1.0	2.2	1.15	1.0	.8	....
29	2.2	....	2.1	1.5	1.0	.8	....
30	2.0	....	2.05	1.4	.9	.8	....
31	1.9	....	2.0	....	1.1	....	....

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	....	....	....	....	....	1.85	1.65	0.85	0.8	0.95	0.8	1.4
2	....	....	....	....	....	2.65	1.4	.85	.8	.95	.9	1.3
3	....	....	....	....	....	2.4	1.3	.85	.8	.9	.9	1.2
4	....	....	....	....	....	2.1	1.25	.85	.85	.85	.9	1.1
5	....	....	....	....	....	1.9	1.1	.85	.8	.85	.9	1.1
6	....	....	....	....	....	1.85	1.2	.9	.75	.85	.9	1.1
7	....	....	....	....	2.65	1.75	1.15	.9	.7	.85	.8	1.1
8	....	....	....	....	2.4	1.6	1.05	.9	.7	.8	.8	1.05
9	....	....	....	....	2.2	1.5	1.0	.9	.7	.8	.8	1.05
10	....	....	....	....	2.0	1.5	.9	.9	.75	.8	.8	1.05
11	....	....	....	....	1.9	1.45	1.0	.9	.75	.8	.8	1.05
12	....	....	....	....	1.75	2.3	1.0	.9	.8	.8	.8	1.05
13	....	....	....	....	1.7	4.3	1.0	.9	.8	.8	.8	1.05
14	....	....	....	....	1.65	3.1	1.0	.9	.8	.8	.95	1.05
15	....	....	....	....	1.6	2.4	.9	.9	.8	.8	.9	1.8
16	....	....	....	....	1.5	2.1	1.0	.9	.8	.8	.8	1.9
17	....	....	....	....	1.45	2.0	1.0	.9	.8	.8	.8	1.8
18	....	....	....	....	1.4	1.85	1.0	.85	.8	.8	.8	1.75
19	....	....	....	....	1.3	1.75	1.0	.85	.9	.8	.8	1.7
20	....	....	....	....	1.3	1.55	.95	.8	1.05	.8	.9	1.6

Daily gage height, in feet, of Roanoke River at Roanoke, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
21	......	......	......	......	1.8	1.5	.95	.8	.85	.8	.9	1.6
22	......	......	......	......	1.25	1.45	.9	.8	.9	.8	.9	1.8
23	......	......	......	......	1.2	1.4	.9	1.0	6.7	.8	1.4	2.5
24	......	......	......	......	1.2	1.4	.9	1.05	2.8	.8	2.7	2.6
25	......	......	......	......	1.2	2.0	.9	.95	1.9	.8	2.4	2.5
26	......	......	......	......	1.2	1.55	.9	.9	1.8	.8	2.5	2.05
27	......	......	......	......	1.2	1.5	.9	.9	1.45	.8	2.4	2.8
28	......	......	......	......	1.2	1.45	.9	.8	1.8	.9	2.3	2.4
29	......	......	......	......	1.05	1.4	.9	.8	1.2	.9	2.1	2.6
30	......	......	......	......	1.05	1.7	.85	.8	1.1	.9	1.8	2.8
31	......	......	......	......	1.05	......	.85	.8	......	.9	......	2.95
1908												
1	2.90	0.90	1.70	1.80	1.65	1.25	1.80	.95	1.00	.90	2.10	1.30
2	2.80	.90	1.70	1.80	1.48	1.15	1.20	.87	.97	.82	1.80	1.28
3	2.75	.90	1.75	1.60	1.40	1.12	1.18	.82	.93	.80	1.75	1.20
4	2.75	1.00	1.75	3.50	1.48	1.55	2.50	.85	.90	.80	1.65	1.15
5	2.60	1.05	1.60	2.15	1.87	2.65	1.95	.83	.90	.80	1.55	1.15
6	2.60	1.85	1.65	1.90	1.40	2.05	3.00	.90	3.00	.80	1.48	1.20
7	2.55	1.50	1.65	1.80	1.70	1.80	2.05	.87	1.85	.75	1.40	1.45
8	2.55	1.60	1.60	1.80	2.40	1.65	1.70	.87	1.90	.78	1.40	2.00
9	2.50	1.50	1.60	1.60	2.20	1.50	1.40	.92	1.40	.75	1.35	1.80
10	2.50	1.55	1.50	1.60	1.88	1.50	1.35	1.00	1.30	1.20	1.30	1.65
11	2.90	1.50	1.55	1.60	1.62	1.45	1.30	.90	1.20	2.00	1.35	1.50
12	3.30	1.60	1.50	1.50	1.58	2.95	1.18	.90	1.10	1.50	1.30	1.85
13	3.10	1.60	1.55	1.55	1.47	1.75	1.15	.85	1.05	1.25	1.30	1.95
14	2.90	1.70	1.55	1.50	1.35	1.65	1.10	.78	1.05	1.15	1.25	1.85
15	2.80	1.60	1.50	1.40	1.20	1.55	1.05	.80	1.00	1.10	1.30	1.70
16	2.75	1.60	1.60	1.50	1.35	1.45	1.00	.90	.95	1.00	1.30	1.60
17	2.60	1.70	1.65	1.55	1.28	1.30	1.00	1.05	.93	.98	1.35	1.50
18	2.50	1.60	1.65	1.40	1.23	1.25	.98	.95	.92	.98	1.55	1.48
19	2.35	1.75	1.70	1.40	1.60	1.18	.95	.93	.90	.95	2.50	1.45
20	2.05	1.70	1.60	1.40	1.65	1.16	.97	.85	.90	.90	2.20	1.40
21	1.75	1.80	1.70	1.20	1.85	1.25	.95	.82	.90	.90	2.00	1.85
22	1.75	1.85	1.70	1.30	2.00	1.30	1.00	.80	.90	.92	1.75	1.35
23	1.70	1.90	1.80	1.20	2.05	1.30	.98	1.05	.89	.97	1.65	1.45
24	1.60	1.80	1.80	1.10	1.90	1.28	1.65	.90	.87	6.70	1.55	1.45
25	1.50	1.70	1.70	1.30	1.78	1.17	1.10	1.05	.85	2.80	1.50	1.70
26	1.30	1.80	1.75	1.30	1.60	1.10	1.00	2.45	.85	2.20	1.48	2.70
27	1.20	1.70	1.70	1.30	1.50	1.15	1.00	1.55	.84	1.85	1.45	2.40
28	1.05	1.70	1.70	1.55	1.40	1.05	1.40	1.32	1.00	1.70	1.40	2.10
29	1.05	1.70	1.70	1.45	1.40	1.00	1.15	1.25	1.00	3.45	1.35	2.55
30	1.00	......	1.70	......	1.40	.98	1.10	1.15	.95	3.30	1.30	3.65
31	.90	......	1.80	......	1.30	......	1.00	1.05	......	2.55	......	3.20
1909												
1	3.0	1.4	2.0	1.48	3.0	1.85	1.4	1.0	0.8	0.8	0.85	0.8
2	2.5	1.4	2.1	1.48	2.6	1.75	1.3	1.65	.8	.8	.85	.8
3	2.2	1.45	2.15	1.45	2.3	1.65	1.25	1.5	.75	.7	.75	.8
4	2.0	1.45	2.1	1.4	2.0	2.3	1.1	1.85	.75	.8	.8	.8
5	3.05	1.45	2.05	1.35	1.85	2.05	1.1	1.05	.7	.8	.8	.8
6	3.05	1.4	2.2	1.32	1.75	1.95	1.2	2.25	.8	.65	.7	.8
7	2.5	1.4	2.25	1.3	1.65	1.85	2.0	2.25	.8	.75	.8	.8
8	2.3	1.38	2.2	1.27	1.6	1.6	1.4	1.7	.85	.75	.8	.95
9	2.0	1.45	2.1	1.25	1.5	2.1	1.3	1.45	.85	.65	.7	.9
10	1.9	3.1	2.05	1.22	1.8	1.8	1.25	1.05	1.45	.75	.8	.9
11	1.8	2.4	1.85	1.22	2.0	1.7	1.2	1.0	1.2	1.7	.8	.9
12	1.7	2.0	1.82	1.2	1.8	1.6	1.15	1.0	1.0	1.75	.7	.9
13	1.65	1.95	1.79	1.3	1.65	1.5	1.1	1.0	.8	1.7	.8	.9
14	1.55	1.8	1.75	7.5	1.55	1.45	1.1	1.05	.85	1.5	.8	1.5
15	1.65	1.75	1.65	3.5	1.5	1.4	1.05	1.4	.85	1.1	.7	1.2

Daily gage height, in feet, of Roanoke River at Roanoke, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
16	1.8	1.7	1.58	2.6	1.45	1.35	1.0	1.5	.8	1.0	.8	1.0
17	2.1	1.6	1.54	2.2	1.4	1.35	1.2	1.25	.9	.95	.8	.95
18	2.6	1.5	1.5	2.0	1.35	1.35	1.1	1.1	.9	.8	.7	.9
19	2.5	1.6	1.45	1.85	1.3	1.3	1.0	1.0	.8	.9	.8	.85
20	2.35	1.6	1.45	1.75	1.35	1.3	.95	.9	.9	.9	.8	.8
21	2.35	1.5	1.45	1.7	6.65	1.25	.95	.9	.9	.8	.7	.5
22	2.3	1.5	1.4	1.7	3.7	1.2	.9	.9	.8	.85	.8	.4
23	2.3	1.6	1.38	1.7	3.5	1.2	.93	.85	.9	.85	.8	.0
24	2.25	2.0	1.3	1.65	3.1	1.2	.9	.85	.85	.7	.7	.4
25	2.15	2.0	1.65	1.65	3.0	1.2	.8	.75	.75	.8	.8	.6
26	2.0	1.95	1.8	1.6	4.2	1.2	.85	.83	.83	.8	.8	.7
27	1.9	1.9	1.65	1.6	4.6	1.15	.95	.8	.83	.7	.7	.3
28	1.85	1.9	1.6	1.6	3.1	1.15	.9	.8	.7	.8	.8	.5
29	1.75	....	1.58	1.5	2.5	1.2	.9	.8	.8	.8	.8	.65
30	1.65	....	1.55	1.7	2.2	1.9	.9	.7	.8	.7	.7	.7
31	1.5	....	1.5	....	2.0	....	.95	.8	....	.8	....	.6
1910												
1	0.45	0.9	1.6	0.9	1.2	1.1	1.3	1.1	1.3	0.7	0.8	0.75
2	.6	1.1	2.85	.95	1.15	.95	1.35	1.05	1.25	.75	.8	.7
3	.9	1.2	2.1	.95	1.1	.9	1.25	1.05	1.35	.75	.75	.65
4	.9	1.4	2.0	1.1	1.15	.85	1.25	1.1	1.35	.7	.8	.7
5	.95	1.45	1.9	1.15	1.1	1.0	2.0	1.0	1.5	.75	.7	.75
6	.8	1.1	1.9	1.05	1.1	1.25	1.45	1.05	1.25	.7	.75	.9
7	1.3	1.35	1.85	1.1	1.1	1.0	1.85	.95	1.05	.85	.75	1.0
8	1.75	1.4	1.7	1.05	1.1	1.0	1.55	.95	1.05	1.25	.7	.85
9	1.5	1.3	1.6	.95	1.25	1.05	2.0	1.0	.95	1.65	.7	.9
10	1.25	1.25	1.6	1.0	1.15	1.25	1.9	.9	.95	1.2	.65	.85
11	1.15	1.1	1.5	.95	1.2	2.4	1.75	.95	.9	1.05	.7	.85
12	1.0	1.1	1.4	1.0	1.15	3.05	1.3	.9	.85	1.0	.7	.85
13	1.05	1.0	1.4	1.15	1.1	7.75	1.4	.9	.9	1.0	.65	.8
14	1.0	1.0	1.3	1.1	1.1	6.25	1.9	.9	.85	.85	.7	.85
15	.9	1.15	1.25	1.15	1.05	3.5	1.9	.85	.95	.9	.65	.8
16	.85	1.3	1.2	1.05	1.05	4.3	1.75	.9	.85	.85	.7	.75
17	.9	2.0	1.15	1.15	1.05	3.25	1.9	.8	.85	.85	.7	.75
18	.95	4.6	1.2	1.7	.95	2.7	4.25	.8	.85	.85	.65	.7
19	1.0	2.55	1.2	1.55	1.0	2.25	2.35	.9	.75	.8	.65	.8
20	1.0	1.95	1.15	1.55	.9	2.0	2.0	1.0	.8	.9	.6	.7
21	1.85	1.9	1.15	1.45	1.0	1.9	1.75	.9	.75	.85	.65	.4
22	2.1	1.9	1.1	1.5	1.0	2.1	1.5	.85	.75	.9	.7	.5
23	1.9	1.85	1.1	1.45	1.0	2.05	1.35	.8	.8	.9	.65	.7
24	1.6	1.8	1.1	1.35	1.15	1.95	1.35	.85	.75	.85	.7	.9
25	1.5	1.65	1.05	1.3	1.4	2.45	1.3	.8	.8	.9	.65	.95
26	1.25	1.65	1.0	1.25	1.25	2.0	1.25	.85	.8	.85	.7	.95
27	1.2	1.6	.95	1.25	1.25	1.55	1.2	.95	.8	.9	.7	.95
28	1.2	1.45	1.0	1.25	1.2	1.9	1.15	.9	.8	.9	.7	.85
29	1.1	....	.95	1.15	1.25	1.45	1.1	.95	.75	.8	.75	.9
30	1.0	....	.95	1.2	1.15	1.4	1.15	.85	....	.85	.7	1.2
31	.95	....	.95	....	1.15	....	1.05	1.0	....	.75	....	1.4
1911												
1	1.9	2.0	1.2	1.75	1.55	1.0	0.9	0.68	1.2	0.68	0.8	1.0
2	2.75	1.8	1.15	1.65	1.5	1.0	.9	.68	1.0	.68	.8	.9
3	2.9	1.6	1.15	1.65	1.35	1.0	.85	.68	.95	.68	.8	.9
4	3.2	1.45	1.1	2.5	1.3	1.0	.85	.75	.85	.65	.8	.9
5	2.2	1.4	1.1	4.0	1.3	1.7	1.8	1.1	.8	.65	.8	.9
6	1.9	1.3	2.45	4.0	1.25	1.2	1.0	1.2	.75	.65	.8	.9
7	1.65	1.3	2.7	3.8	1.25	1.1	.9	.8	.75	.7	1.8	.9
8	1.5	1.3	2.2	3.3	1.25	1.7	2.4	.75	.7	.75	1.2	.9
9	1.4	1.3	2.0	2.7	1.25	1.3	1.6	.7	.7	.75	1.3	.9
10	1.35	2.6	3.1	2.5	1.25	1.2	1.2	.68	.7	.75	1.3	.75

Daily gage height, in feet, of Roanoke River at Roanoke, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
11	1.3	2.0	2.9	2.3	1.2	1.1	1.2	.68	.8	.85	1.4	.75
12	1.25	1.85	2.8	2.1	1.2	1.05	1.2	.68	1.0	.8	1.3	.75
13	1.15	1.75	2.6	2.3	1.15	1.0	1.2	.9	.9	.75	1.2	.75
14	1.1	1.6	2.2	2.65	1.15	1.0	1.2	.8	.9	.7	1.2	.75
15	1.05	1.5	2.1	2.5	1.1	1.2	1.0	.75	.85	.7	1.2	1.0
16	1.0	1.4	2.0	2.45	1.1	1.1	.95	.7	.85	.7	1.2	1.4
17	1.0	1.4	1.9	2.4	1.1	1.0	.9	.68	.8	.7	1.2	2.0
18	1.0	1.4	1.9	2.1	1.05	1.0	.9	.67	.75	3.75	1.2	1.7
19	1.0	1.4	1.8	2.0	1.05	1.0	.9	.65	.75	1.5	1.2	1.5
20	1.0	1.5	1.8	2.0	1.0	1.0	.85	.65	.75	1.2	1.2	1.4
21	1.0	1.5	1.8	1.95	1.0	.95	.85	.65	.7	1.1	1.2	1.3
22	1.0	1.45	1.7	1.85	1.0	.9	.8	.62	.7	1.1	1.1	1.3
23	2.0	1.4	1.55	1.8	1.0	.9	.75	.62	.75	1.2	1.1	2.9
24	1.9	1.4	1.5	1.7	1.0	.9	.75	.6	.75	1.1	1.1	2.9
25	1.8	1.35	1.4	1.65	1.0	.9	.75	.6	.7	1.05	1.1	2.9
26	1.5	1.3	1.4	1.55	.95	1.2	.7	.6	.7	1.0	1.0	2.9
27	1.4	1.25	1.6	1.5	.95	1.1	.7	.6	.7	1.0	1.0	3.0
28	1.4	1.2	1.6	1.5	.95	1.0	.7	.6	.68	.9	1.0	2.9
29	1.4	....	1.55	1.5	.95	.9	.7	.7	.68	.9	1.0	2.6
30	2.5	....	1.65	1.5	1.0	.9	.7	1.5	.68	.85	1.0	2.0
31	2.2	....	1.85	....	1.0	....	.7	1.2	....	.85	....	1.9
1912												
1	1.8	1.8	2.2	3.8	1.7	1.3	1.7	1.2	0.8	1.1	0.8	0.9
2	1.7	1.6	1.8	3.2	1.7	1.3	1.6	1.1	.8	1.1	.8	.9
3	1.6	1.4	1.8	2.9	1.7	1.3	1.5	1.1	.8	1.0	.8	.8
4	1.55	1.4	1.8	2.6	1.6	1.2	1.4	1.0	.8	1.0	.8	.9
5	1.4	1.2	1.8	2.4	1.5	1.2	1.6	1.0	.8	.95	.8	.9
6	1.3	1.2	1.7	2.3	1.4	1.2	1.4	1.0	.8	.9	.8	1.3
7	1.25	1.2	1.6	2.2	1.4	1.2	1.4	1.0	.8	.9	1.6	1.4
8	1.25	1.2	1.7	2.1	1.4	1.2	1.3	1.0	.8	.8	1.8	1.3
9	1.2	1.15	1.8	2.0	1.3	1.1	1.5	1.0	.8	.8	1.4	1.3
10	1.2	1.1	2.5	1.9	1.3	1.1	1.5	.95	.8	.8	1.3	1.2
11	1.2	1.1	2.2	1.8	1.3	1.1	1.8	.95	.8	.8	1.2	1.1
12	1.2	1.1	2.4	1.7	8.5	1.1	1.6	.95	.8	.8	1.2	1.1
13	1.2	1.1	4.5	1.6	4.4	1.1	1.4	.90	.8	.8	1.1	1.1
14	1.2	1.1	7.6	1.6	3.8	1.1	1.5	.90	.8	.8	1.1	1.1
15	1.2	1.1	5.5	1.5	4.0	1.1	1.3	.90	.8	.8	1.0	1.1
16	1.0	1.1	4.2	1.5	4.5	1.1	1.2	.90	.8	.8	1.0	1.1
17	1.1	1.1	3.1	1.5	5.0	1.1	1.1	.90	1.0	.8	1.0	1.0
18	1.2	1.1	2.9	1.4	4.0	1.1	1.1	.90	1.2	.8	1.0	1.0
19	1.4	1.1	2.4	1.4	3.0	1.1	1.4	.85	.9	.8	1.0	1.0
20	1.7	1.1	2.3	1.4	2.2	1.2	1.5	.85	.9	.8	1.0	1.0
21	1.5	1.2	2.0	1.4	2.0	1.1	1.7	.85	.85	.8	1.0	1.0
22	1.4	3.6	2.6	1.4	1.9	1.2	1.7	.85	.85	.8	.9	1.0
23	1.4	2.2	2.7	1.3	1.8	1.2	1.6	.90	.9	.8	.9	1.0
24	1.4	2.1	2.5	1.3	1.7	1.25	1.5	.90	1.1	.8	.9	1.0
25	1.3	2.2	2.4	1.3	1.6	1.7	1.5	.90	3.3	.8	.9	1.0
26	1.3	2.8	2.3	1.3	1.5	1.3	1.4	.85	2.2	.8	.9	1.0
27	1.2	4.2	2.2	1.2	1.5	2.6	1.4	.85	2.0	.8	.9	1.0
28	1.2	3.1	2.2	1.2	1.4	2.4	1.4	.85	1.8	.8	.9	1.0
29	1.2	2.8	7.2	1.3	1.4	1.7	1.3	.85	1.6	.8	.9	1.0
30	1.8	....	4.1	1.6	1.3	1.6	1.25	.85	1.3	.8	.9	1.1
31	2.1	....	4.0	....	1.3	....	1.2	.80	....	.8	....	1.7
1913												
1	1.5	1.4	2.1	1.8	1.1	1.6	1.2	0.8	0.7	0.7	0.9	1.0
2	1.4	1.4	1.9	1.7	1.0	1.5	1.1	.75	.65	.7	.9	2.0
3	1.4	1.4	1.7	1.6	1.0	1.4	1.9	.75	.65	.7	.9	1.7
4	1.4	1.4	1.5	1.5	1.0	1.4	2.8	.7	.7	.7	.85	1.5
5	1.5	1.4	1.4	1.5	1.0	1.3	2.5	.7	1.1	.7	.8	1.4

Daily gage height, in feet, of Roanoke River at Roanoke, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
6	1.4	1.3	1.3	1.4	1.0	1.3	1.8	.7	.9	.65	.8	1.3
7	1.3	1.2	1.2	1.3	1.0	1.2	1.5	.75	.7	.7	.8	1.3
8	1.2	1.1	1.2	1.3	1.0	1.6	1.3	.75	.6	.65	.8	1.4
9	1.1	1.1	1.2	1.3	1.0	1.5	1.2	.75	.7	.8	3.0	1.3
10	1.1	1.1	1.2	1.3	1.0	1.3	1.1	1.9	....	1.2	2.3	1.2
11	1.1	1.1	1.4	1.3	.9	1.2	1.2	1.7	....	1.2	1.8	1.2
12	1.0	1.1	1.3	1.6	.9	1.3	1.5	.9	....	1.1	1.5	1.1
13	1.2	1.0	1.3	2.6	.9	1.3	1.2	.9	....	1.1	1.5	1.1
14	1.1	1.0	7.7	2.1	.9	1.2	1.1	1.0	....	.9	1.3	1.0
15	1.0	1.0	4.0	1.9	.9	1.1	1.0	.9	....	.9	1.3	1.0
16	1.0	1.0	3.4	1.9	1.0	1.1	1.0	.9	....	.8	1.2	1.0
17	1.0	1.0	2.4	1.8	1.2	1.0	1.0	.7	....	.8	1.2	1.0
18	1.0	.9	2.2	1.7	1.2	1.0	.9	.7	....	.8	1.2	1.0
19	1.0	.9	1.9	1.6	1.0	1.0	.9	1.1	....	.85	1.2	1.0
20	.9	.9	1.8	1.6	.9	1.0	.9	1.2	....	1.3	1.1	.9
21	.9	1.0	1.7	1.5	1.0	.9	.9	1.1	....	1.7	1.1	.9
22	.9	1.0	1.6	1.4	1.1	1.0	.8	1.0	....	1.4	1.1	.9
23	.9	1.0	1.5	1.3	3.9	1.7	.8	.9	....	1.2	1.0	.9
24	.9	1.0	1.5	1.3	5.7	2.2	.8	.9	.9	1.2	1.0	1.0
25	.9	1.0	1.4	1.3	3.0	1.3	.75	.8	.9	1.4	1.0	1.0
26	.9	.9	1.4	1.2	2.4	1.2	.9	.7	.8	1.3	.9	2.3
27	1.0	1.6	3.4	1.2	2.0	1.6	.75	.7	.8	1.2	.9	1.8
28	2.5	2.9	3.5	1.2	2.8	1.4	.75	.7	.8	1.1	.9	1.7
29	1.9	....	2.4	1.2	2.2	1.8	1.1	.7	.7	1.1	.9	1.4
30	1.6	....	2.1	1.1	2.0	1.5	.9	.7	.7	1.0	.9	1.4
31	1.5	....	2.0	....	1.8	....	.8	.7	....	.9	....	1.3
1914												
1	1.3	2.5	1.9	2.7	1.3	0.9	0.7	....	0.8	0.6	0.7	2.5
2	1.2	2.1	1.7	2.6	1.3	.9	2.1	....	.6	.6	.7	2.7
3	1.2	1.9	1.7	2.3	1.3	.8	1.2	....	1.0	.6	.7	2.1
4	1.4	1.7	1.7	2.1	1.3	.8	.9	0.9	1.0	.6	.7	1.8
5	1.4	1.7	1.6	1.9	1.3	.8	.9	.7	.8	.9	.7	9.3
6	1.4	1.9	1.6	1.8	1.3	.9	.9	.8	.8	1.0	.7	3.7
7	1.5	3.3	1.6	1.7	1.3	.9	.9	.8	.7	.8	.7	2.9
8	1.5	2.7	1.6	1.7	1.3	.9	.9	.8	.6	.7	.7	2.5
9	2.0	2.3	1.6	1.9	1.3	.9	.8	....	.7	.8	.7	2.1
10	3.2	2.1	1.5	1.6	1.3	.9	2.1	....	.7	.8	.7	2.0
11	2.4	1.9	1.6	1.6	1.2	.8	1.1	.9	.7	.7	.7	2.0
12	2.2	1.8	2.5	1.5	1.2	.8	.9	.8	.6	.7	.7	1.8
13	1.8	1.7	2.6	1.5	1.1	.8	.9	.9	.8	.7	.7	1.7
14	1.6	1.5	2.3	1.5	1.1	.8	3.0	.8	.7	.8	.7	1.8
15	1.6	1.5	2.2	1.7	1.1	.8	1.9	.7	.6	.9	1.7	1.5
16	1.5	1.6	2.2	2.2	1.1	.8	1.8	.7	.7	2.7	1.1	1.4
17	1.5	1.3	2.2	2.0	1.1	.8	2.7	.7	.7	1.9	1.5	1.4
18	1.4	1.6	2.7	1.9	1.1	.7	2.7	.6	.6	1.4	1.2	1.4
19	1.4	2.7	2.6	1.8	1.0	.7	1.4	.7	.8	1.2	1.1	1.3
20	1.4	3.7	2.4	1.8	1.0	.7	1.1	.6	.9	1.1	1.0	2.0
21	1.7	3.4	2.2	1.8	1.0	.7	1.1	.6	.8	1.0	1.0	2.3
22	1.9	2.8	2.1	1.7	1.0	.7	1.0	.9	.6	.9	.9	2.9
23	1.7	2.6	2.0	1.6	1.0	.7	.9	.8	.7	.9	1.0	2.3
24	1.6	2.4	1.9	1.6	1.0	.7	.9	.7	.7	.8	.9	2.0
25	1.6	2.1	1.7	1.5	1.0	.7	.8	.5	.6	.9	.8	1.9
26	2.0	2.0	1.8	1.5	.9	.7	.8	1.0	.7	.8	.8	1.8
27	1.8	2.0	1.7	1.5	.9	.7	1.4	.9	.7	.8	.8	1.7
28	1.7	1.9	1.6	1.4	.9	.7	1.1	.8	.6	.8	.8	1.7
29	1.6	....	1.7	1.4	.9	.7	1.1	1.0	.7	.8	.8	1.7
30	1.4	....	1.7	1.3	.9	.7	.8	1.0	.7	.8	1.1	2.5
31	1.9	....	1.8	....	.9	....	.9	.9	....	.7	....	2.7

NOTE.—Discharge relation affected by ice at headwaters, which retarded the flow Dec. 21, 1909, to Jan. 2, 1910, and Dec. 21-22, 1910. Gage heights estimated from observer's notes June 27, 1912, and by the observer Nov. 19-21 and possibly other days in 1912. Gage was stolen Sept. 10 and replaced Sept. 24, 1913.

Daily discharge, in second-feet, of Roanoke River at Roanoke, Va., for 1906–1914.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	335	590	186	960	335	224	122	......	......	......	......	......
2	310	530	224	763	310	186	122	......	......	......	......	......
3	3,985	470	244	560	310	152	109	......	......	......	......	......
4	2,390	415	530	500	264	96	109	......	......	......	......	......
5	1,440	415	415	443	224	122	96	......	......	......	......	......
6	840	415	360	415	264	122	96	......	......	......	......	......
7	622	360	310	388	310	122	96	......	......	......	......	......
8	560	360	310	360	310	122	96	......	......	......	......	......
9	500	335	310	360	310	96	96	......	......	......	......	......
10	415	310	264	530	224	122	96	......	......	......	......	......
11	415	264	264	470	224	122	96	......	......	......	......	......
12	415	264	264	443	224	122	85	......	......	......	......	......
13	360	264	264	360	186	360	85	......	......	......	......	......
14	360	264	244	360	186	310	85	......	......	......	......	......
15	415	264	360	590	152	264	96	......	......	......	......	......
16	415	264	415	725	186	224	......	......	......	......	......	......
17	415	264	725	622	186	186	......	......	......	......	......	......
18	388	224	800	530	186	186	......	......	......	......	......	......
19	360	224	880	470	186	152	......	......	......	......	......	......
20	335	224	880	415	152	122	......	......	......	......	......	......
21	310	224	880	360	360	224	......	......	......	......	......	......
22	310	205	800	470	310	186	......	......	......	......	......	......
23	2,972	205	725	415	360	152	......	......	......	......	......	......
24	1,340	205	590	360	360	122	......	......	......	......	......	......
25	880	205	530	310	264	122	......	......	......	......	......	......
26	763	205	470	310	224	122	......	......	......	......	......	......
27	622	224	840	264	186	122	......	......	......	......	......	......
28	310	186	880	244	186	122	......	......	......	......	......	......
29	880	......	800	415	186	122	......	......	......	......	......	......
30	725	......	763	360	152	122	......	......	......	......	......	......
31	655	......	725	......	224	......	......	......	......	......	......	......
1907												
1	......	......	......	......	......	665	539	178	162	213	162	404
2	......	......	......	......	......	1,320	404	178	162	213	195	357
3	......	......	......	......	......	1,090	357	178	162	195	195	313
4	......	......	......	......	......	840	335	178	178	178	195	271
5	......	......	......	......	......	700	271	178	162	178	195	271
6	......	......	......	......	......	665	313	195	147	178	195	271
7	......	......	......	......	1,320	599	292	195	132	178	162	271
8	......	......	......	......	1,090	510	251	195	132	162	162	251
9	......	......	......	......	920	455	231	195	132	162	162	251
10	......	......	......	......	770	455	195	195	147	162	162	251
11	......	......	......	......	700	430	231	195	147	162	162	251
12	......	......	......	......	599	1,000	231	195	162	162	162	251
13	......	......	......	......	568	3,310	231	195	162	162	162	251
14	......	......	......	......	539	1,790	231	195	162	162	213	251
15	......	......	......	......	510	1,090	195	195	162	162	195	630
16	......	......	......	......	455	840	231	195	162	162	162	700
17	......	......	......	......	430	770	231	195	162	162	162	630
18	......	......	......	......	404	665	231	178	162	162	162	599
19	......	......	......	......	357	599	231	178	195	162	162	568
20	......	......	......	......	357	482	213	162	251	162	195	510
21	......	......	......	......	357	455	213	162	178	162	195	510
22	......	......	......	......	335	430	195	162	195	162	195	630
23	......	......	......	......	313	404	195	231	6,550	162	404	1,180
24	......	......	......	......	313	404	195	251	1,000	162	1,370	1,270
25	......	......	......	......	313	770	195	213	700	162	1,090	1,180

Daily discharge, in second-feet, of Roanoke River at Roanoke, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
26	......	......	......	......	318	482	195	195	630	162	1,180	805
27	......	......	......	......	318	455	195	195	430	162	1,090	1,000
28	......	......	......	......	318	430	195	162	357	195	1,000	1,090
29	......	......	......	......	251	404	195	162	313	195	840	1,270
30	......	......	......	......	251	568	178	162	271	195	630	1,470
31	......	......	......	......	251	......	178	162	......	195	......	1,620
1908												
1	1,550	152	530	590	500	287	310	169	186	152	800	310
2	1,440	152	530	590	404	244	264	143	176	128	590	301
3	1,390	152	560	470	360	232	256	128	162	122	560	264
4	1,390	186	560	2,260	404	442	1,140	137	152	122	500	244
5	1,240	205	470	840	345	1,290	690	131	152	122	442	244
6	1,240	335	500	655	360	762	1,660	152	1,660	122	404	264
7	1,190	415	500	590	530	590	762	143	622	109	360	388
8	1,190	470	470	590	1,050	500	530	143	655	117	360	725
9	1,140	415	470	470	880	415	360	159	360	109	335	590
10	1,140	442	415	470	610	415	335	186	310	264	310	500
11	1,550	415	442	470	482	388	310	152	264	725	335	415
12	9,380	470	415	415	432	1,600	256	152	224	415	310	622
13	1,780	470	442	442	398	560	244	137	205	287	310	690
14	1,550	530	442	415	335	500	224	117	205	244	287	622
15	1,440	470	415	360	264	442	205	122	186	224	310	530
16	1,390	470	470	415	335	388	186	152	169	186	310	470
17	1,240	530	500	442	301	310	186	205	162	179	335	415
18	1,140	470	500	360	278	287	179	169	159	179	442	404
19	1,000	560	530	360	470	256	169	162	152	169	1,140	388
20	762	530	470	360	500	248	176	137	152	152	880	360
21	560	590	530	264	622	287	169	128	152	152	725	335
22	560	622	530	310	725	310	186	122	152	159	560	335
23	530	655	590	264	762	310	179	205	149	176	500	388
24	470	590	590	224	655	278	500	152	143	6,550	442	388
25	415	530	530	310	548	252	224	205	137	1,440	415	530
26	310	590	560	310	470	224	186	1,100	137	880	404	1,340
27	264	530	530	310	415	244	186	442	134	622	388	1,050
28	205	530	530	442	360	205	360	320	186	530	360	800
29	205	530	530	388	360	186	244	287	186	2,200	335	1,190
30	186	......	530	444	360	179	224	244	169	2,020	310	2,450
31	152	......	590	......	310	......	186	205	......	1,190	......	1,900
1909												
1	1,660	326	690	366	1,660	585	326	166	110	110	123	110
2	1,130	326	770	366	1,230	519	279	459	110	110	123	110
3	850	351	810	351	940	459	258	376	98	86	98	110
4	690	351	770	326	690	940	200	302	98	110	110	110
5	1,720	351	730	302	585	730	200	183	86	110	110	110
6	1,720	326	850	288	519	655	237	895	110	75	86	110
7	1,130	326	895	279	459	585	690	894	110	98	110	110
8	940	317	850	266	430	430	326	488	123	98	110	151
9	690	351	770	258	376	770	279	351	123	75	86	136
10	620	1,780	730	245	550	550	258	183	351	98	110	136
11	550	1,030	585	245	690	488	237	166	237	488	110	136
12	488	690	564	237	550	430	218	166	106	519	86	136
13	459	655	544	279	459	376	200	166	110	488	110	136
14	403	550	519	7,630	408	351	200	183	123	376	110	376
15	459	519	459	2,260	376	326	183	326	123	200	86	237
16	550	488	419	1,230	351	302	166	376	110	166	110	166
17	770	430	398	850	326	302	237	258	136	151	110	151
18	1,230	376	376	690	302	302	200	200	136	110	86	136
19	1,130	430	351	585	279	279	166	166	110	136	110	123
20	985	430	351	519	302	279	151	136	136	136	110	110

Daily discharge, in second-feet, of Roanoke River at Roanoke, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
21	985	376	351	488	6,480	258	151	136	136	110	86	....
22	940	376	326	488	2,520	237	136	136	110	123	110	....
23	940	430	317	488	2,260	237	145	123	136	123	110	....
24	895	690	279	459	1,780	237	136	123	123	86	86	....
25	810	690	459	459	1,660	237	110	98	98	110	110	....
26	690	655	550	430	3,180	237	123	118	118	110	110	....
27	620	620	459	430	3,720	218	151	110	118	86	86	....
28	585	620	430	430	1,780	218	136	110	86	110	110	....
29	519	....	419	376	1,130	237	136	110	110	110	110	....
30	459	....	403	488	850	620	136	86	110	86	86	....
31	376	....	376	....	690	....	151	110	....	110	....	....
1910												
1	60	136	430	136	237	200	310	224	310	96	122	109
2	80	200	1,490	151	218	151	335	205	287	109	122	96
3	136	237	770	151	200	136	287	205	335	109	109	85
4	136	326	690	200	218	123	287	224	335	96	122	96
5	151	351	620	218	200	166	725	186	415	109	96	109
6	110	200	620	183	200	258	388	205	287	96	109	152
7	279	302	585	200	200	166	622	169	205	187	109	186
8	519	326	488	183	200	166	442	169	205	287	96	137
9	376	279	430	151	258	183	725	186	169	500	96	152
10	258	258	430	166	218	258	655	152	169	264	85	137
11	218	200	376	151	237	1,030	560	169	152	205	96	137
12	166	200	326	166	218	1,720	310	152	137	186	96	137
13	183	166	326	218	200	7,970	360	152	152	186	85	122
14	166	166	279	200	200	5,940	655	152	137	137	96	137
15	136	218	258	218	183	2,260	655	137	169	152	85	122
16	123	279	237	183	183	3,310	560	152	187	137	96	109
17	136	690	218	218	183	1,960	655	122	137	137	96	109
18	151	3,720	237	488	151	1,340	3,240	122	187	137	85	96
19	166	1,180	237	403	166	920	1,000	152	109	122	85	122
20	166	655	218	403	136	725	725	186	122	152	74	96
21	585	620	218	351	166	655	560	152	109	187	85	96
22	770	620	200	376	166	800	415	137	109	152	96	96
23	620	585	200	351	166	762	335	122	122	152	85	96
24	430	550	200	302	218	690	335	137	109	137	96	152
25	376	459	183	279	326	1,100	310	122	122	152	85	169
26	258	459	166	258	258	725	287	137	122	137	96	169
27	237	430	151	258	258	442	264	169	122	152	96	169
28	237	351	166	258	237	655	244	152	122	152	96	137
29	200	....	151	218	258	388	224	169	109	122	109	152
30	166	....	151	237	218	360	244	137	102	137	96	264
31	151	....	151	....	218	....	205	186	....	109	....	360
1911												
1	620	690	237	519	408	166	136	82	237	82	110	166
2	1,380	550	218	459	376	166	136	82	166	82	110	136
3	1,540	430	218	459	302	166	123	82	151	82	110	136
4	1,900	351	200	1,130	279	166	123	98	123	76	110	136
5	850	326	200	2,900	279	488	550	200	110	76	110	136
6	620	279	1,080	2,900	258	237	166	237	98	76	110	136
7	459	279	1,330	2,640	258	200	136	110	98	86	550	136
8	376	279	850	2,020	258	488	1,030	98	86	98	237	136
9	326	279	690	1,330	258	279	430	86	86	98	279	136
10	302	1,230	1,780	1,180	258	237	237	82	86	98	279	98
11	279	690	1,540	940	237	200	237	82	110	123	326	98
12	258	585	1,440	770	237	183	237	82	166	110	279	98
13	218	510	1,230	940	218	166	237	136	136	98	237	98
14	200	430	850	1,280	218	166	237	110	136	86	237	98
15	183	376	770	1,130	200	237	166	98	123	86	237	166

Daily discharge, in second-feet, of Roanoke River at Roanoke, Va., for 1906–1914—
Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
16	166	326	690	1,030	200	200	151	86	123	86	237	326
17	166	326	620	1,030	200	166	136	82	110	86	237	690
18	166	326	620	770	183	166	136	80	98	2,580	237	488
19	166	326	550	690	183	166	136	76	98	376	237	376
20	166	376	550	690	166	166	123	76	98	237	237	236
21	166	376	550	655	166	151	123	76	86	200	237	279
22	166	351	488	585	166	136	110	69	86	200	200	279
23	690	326	403	550	166	136	98	69	98	237	200	1,540
24	620	326	376	488	166	136	98	65	98	200	200	1,540
25	550	302	326	459	166	136	98	65	86	183	200	1,540
26	376	279	326	403	151	237	86	65	86	166	166	1,540
27	326	258	430	376	151	200	86	65	86	166	166	1,660
28	326	237	430	376	151	166	86	65	82	136	166	1,540
29	326	....	403	376	151	136	86	86	82	136	166	1,230
30	1,130	....	459	376	166	136	86	376	82	123	166	690
31	850	....	585	....	166	....	86	237	....	123	....	620
1912												
1	550	550	850	2,640	490	282	490	242	115	206	115	143
2	490	430	550	1,900	490	282	430	206	115	206	115	143
3	430	326	550	1,540	490	282	375	206	115	173	115	115
4	402	326	550	1,230	430	242	326	173	115	173	115	143
5	326	242	550	1,030	375	242	430	173	115	158	115	143
6	282	242	490	940	326	242	326	173	115	143	115	282
7	262	242	430	850	326	242	326	173	115	143	430	326
8	262	242	490	770	326	242	282	173	115	115	550	282
9	242	224	550	690	282	206	375	173	115	115	326	282
10	242	206	1,130	620	282	206	375	158	115	115	282	242
11	242	206	850	550	282	206	550	158	115	115	242	206
12	242	206	1,030	490	8,980	206	430	158	115	115	242	206
13	242	206	3,580	430	3,440	206	326	143	115	115	206	206
14	242	206	7,760	430	2,640	206	375	143	115	115	206	206
15	242	206	4,930	375	2,900	206	282	143	115	115	173	206
16	173	206	3,180	375	3,580	206	242	143	115	115	173	206
17	206	206	1,780	375	4,260	206	206	143	173	115	173	173
18	242	206	1,540	326	2,900	206	206	143	242	115	173	173
19	326	206	1,030	326	1,660	206	326	129	143	115	173	173
20	490	206	940	326	850	242	375	129	143	115	173	173
21	375	242	690	326	690	206	490	129	129	115	173	173
22	326	2,390	1,230	326	620	242	490	129	129	115	143	173
23	326	850	1,330	282	550	242	430	143	143	115	143	173
24	326	770	1,130	282	490	262	375	143	206	115	143	173
25	282	850	1,030	282	430	490	375	143	2,020	115	143	173
26	282	1,440	940	282	375	282	326	129	850	115	143	173
27	242	3,180	850	242	375	1,230	326	129	690	115	143	173
28	242	1,780	850	242	326	1,030	326	129	550	115	143	173
29	242	1,440	7,220	282	326	490	282	129	430	115	143	173
30	550	....	3,040	430	282	430	262	129	282	115	143	206
31	770	....	2,900	....	282	....	242	115	....	115	....	490
1913												
1	375	326	770	550	206	430	242	115	89	89	143	173
2	326	326	620	490	173	375	206	102	77	89	143	690
3	326	326	490	430	173	326	620	102	77	89	143	490
4	326	326	375	375	173	326	1,440	89	89	89	129	375
5	375	326	326	375	173	282	1,130	89	206	89	115	326
6	326	282	282	326	173	282	550	89	143	77	115	282
7	282	242	242	282	173	242	375	102	89	89	115	282
8	242	206	242	282	173	430	282	102	65	77	115	326
9	206	206	242	282	173	375	242	102	89	115	1,660	282
10	206	206	242	282	173	282	206	620	65	242	940	242

Daily discharge, in second-feet, of Roanoke River at Roanoke, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	206	206	326	282	143	242	242	490	55	242	550	242
12	173	206	282	430	143	282	375	143	50	206	375	206
13	242	173	282	1,230	143	282	242	143	50	206	375	206
14	206	173	7,900	770	143	242	206	173	50	143	282	173
15	173	173	2,900	620	143	206	173	143	65	143	282	173
16	173	173	2,140	620	173	206	173	143	65	115	242	173
17	173	173	1,030	550	242	173	173	89	50	115	242	173
18	173	143	850	490	242	173	143	89	55	115	242	173
19	173	143	620	430	173	173	143	206	90	129	242	173
20	143	143	550	430	143	173	143	242	140	282	206	143
21	143	173	490	375	173	143	143	206	200	490	206	143
22	143	173	430	326	206	173	115	173	300	326	206	143
23	143	173	375	282	2,780	490	115	143	200	242	173	143
24	143	173	375	282	5,200	850	115	143	143	242	173	173
25	143	173	326	282	1,660	282	102	115	143	326	173	173
26	143	143	326	242	1,030	242	143	89	115	282	143	940
27	173	430	2,140	242	690	430	102	89	115	242	143	550
28	1,130	1,540	2,260	242	1,440	326	102	89	115	206	143	490
29	620	....	1,030	242	850	550	206	89	89	206	143	326
30	430	....	770	206	690	375	143	89	89	173	143	326
31	375	....	690	....	550	....	115	89	....	143	....	282
1914												
1	282	1,130	620	1,330	282	143	89	143	115	65	89	1,130
2	242	770	490	1,230	282	143	770	143	65	65	89	1,330
3	242	620	490	940	282	115	242	143	173	65	89	770
4	326	490	490	770	282	115	143	143	173	65	89	550
5	326	490	430	620	282	115	143	89	115	143	89	10,200
6	326	620	430	550	282	143	143	115	115	173	89	2,520
7	375	2,020	430	490	282	143	143	115	89	115	89	1,540
8	375	1,330	430	490	282	143	143	115	65	89	89	1,130
9	690	940	430	620	282	143	115	124	89	115	89	770
10	1,900	770	375	430	282	143	770	133	89	115	89	690
11	1,030	620	430	430	242	115	206	143	89	89	89	690
12	850	550	1,130	375	242	115	143	115	65	89	89	550
13	550	490	1,230	375	206	115	143	143	115	89	89	490
14	430	375	940	375	206	115	1,660	115	89	115	89	550
15	430	375	850	490	206	115	620	89	65	143	490	375
16	375	430	850	850	206	115	550	89	80	1,330	206	326
17	375	282	850	690	206	115	1,330	89	89	620	375	326
18	326	430	1,330	620	206	89	1,330	65	65	326	242	326
19	326	1,330	1,230	550	173	89	326	89	115	242	206	282
20	326	2,520	1,030	550	173	89	206	65	143	206	173	690
21	490	2,140	850	550	173	89	206	65	115	173	173	940
22	620	1,440	770	490	173	89	173	143	65	143	143	1,540
23	490	1,230	690	430	173	89	143	115	89	143	173	940
24	430	1,030	620	430	173	89	143	89	89	115	143	690
25	430	770	490	375	173	89	115	43	65	143	115	620
26	690	690	550	375	143	89	115	173	89	115	115	550
27	550	690	490	375	143	89	326	143	89	115	115	490
28	490	620	430	326	143	89	206	115	65	115	115	490
29	430	....	490	326	143	89	206	173	89	115	115	490
30	326	....	490	282	143	89	115	173	89	115	206	1,130
31	620	....	550	....	143	....	143	143	....	89	....	1,330

NOTE.—Daily discharge determined as follows: 1906, 1907, 1908; June 14 to Dec. 31, 1910, and 1912 to 1914, from a fairly well-defined rating curve; 1909 to June 13, 1910, and 1911, from a well-defined rating curve; all rating curves coincide above a discharge of about 2,000 second-feet. Discharge Jan. 1-2 and Dec. 21-22, 1910, estimated; Sept. 30, 1910, interpolated; Dec. 21-31, 1909, estimated at 40 second-feet; Sept. 10-23, 1913, estimated by hydrograph comparisons with other stations; maximum and minimum discharge estimates for September, 1913, are therefore approximate.

Monthly discharge of Roanoke River at Roanoke, Va., for 1896–1914.

[Drainage area, 388 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1896						
July 10-31	2,302	91	506	1.30	1.06	
August	162	76	98	.254	.294	
September	2,140	67	154	.397	.443	
October	673	91	142	.366	.422	
November	1,435	91	422	1.09	1.22	
December	707	91	156	.402	.464	
1897						
January	91	67	75	.194	.224	
February	8,710	67	1,514	3.90	4.06	
March	2,710	121	796	2.05	2.36	
April	610	237	404	1.04	1.16	
May	2,905	318	771	1.99	2.29	
June	550	87	378	.974	1.09	
July	673	78	203	.523	.603	
August	550	80	157	.405	.467	
September	610	61	190	.490	.547	
October	673	109	250	.644	.742	
November	109	70	82	.210	.234	
December	290	70	132	.340	.392	
The year	8,710	61	413	1.06	14.17	
1898						
January	1,135	109	454	1.17	1.35	
February	707	121	350	.902	.939	
March	1,720	76	318	.820	.945	
April 1-19	910	290	466	1.20	.848	
May	4,120	85	747	1.93	2.22	
June	521	121	270	.696	.776	
July	550	67	203	.523	.603	
August	1,780	135	570	1.47	1.70	
September	2,327	135	381	.982	1.10	
October	4,255	290	1,028	2.65	3.06	
November	865	347	510	1.31	1.46	
December	2,140	318	659	1.70	1.96	
1899						
January	5,403	550	1,124	2.90	3.34	
February	4,255	745	2,098	5.41	5.63	
March	8,508	785	2,521	6.50	7.49	
April	785	312	482	1.24	1.38	
May	730	189	377	.972	1.12	
June	910	121	278	.717	.800	
July	212	91	130	.335	.386	
August	165	76	105	.271	.312	
September	745	74	133	.343	.383	
October	121	76	88	.227	.262	
November	290	85	128	.330	.368	
December	463	91	173	.446	.514	
The year	8,508	74	636	1.64	21.98	

Monthly discharge of Roanoke River at Roanoke, Va., for 1896–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1900						
January	3,040	91	403	1.04	1.20	
February	3,377	58	689	1.65	1.72	
March	3,512	521	964	2.48	2.86	
April	2,580	263	687	1.77	1.98	
May	1,045	162	320	.825	.951	
June	1,230	162	422	1.09	1.22	
July	610	114	214	.552	.636	
August	121	76	86	.222	.256	
September	707	76	123	.317	.354	
October	3,918	99	381	.982	1.13	
November	8,575	135	593	1.53	1.71	
December	3,486	237	576	1.48	1.71	
The year	8,575	58	451	1.16	15.73	
1901						
January	2,972	169	501	1.29	1.49	
February	393	116	247	.637	.663	
March	2,840	151	531	1.37	1.58	
April	11,610	463	1,702	4.39	4.90	
May	13,600	876	1,446	3.78	4.36	
June	1,804	463	885	2.28	2.54	
July	3,985	189	859	2.21	2.55	
August	16,860	232	1,926	4.96	5.72	
September	1,045	263	454	1.17	1.30	
October	745	181	267	.688	.793	
November	296	151	183	.472	.527	
December	13,570	151	1,425	3.67	4.23	
The year	16,860	116	870	2.24	30.65	
1902						
January	4,525	263	781	2.01	2.32	
February	11,090	212	1,423	3.67	3.82	
March	2,775	347	1,047	2.69	3.10	
April	1,090	376	543	1.40	1.56	
May	376	181	256	.660	.761	
June	318	129	187	.484	.540	
July	463	85	143	.369	.425	
August	158	76	89	.229	.264	
September	85	76	78	.201	.224	
October	673	83	134	.345	.398	
November	1,045	91	239	.616	.687	
December	1,545	189	567	1.46	1.68	
The year	11,090	76	457	1.07	15.78	
1903						
January 1–29	3,040	237	606	1.56	1.68	
February 3–28	8,980	463	1,154	2.97	2.87	
March	6,550	580	1,528	3.94	4.54	
April	2,972	580	1,190	3.07	3.43	
May	785	237	391	1.01	1.16	
June	1,545	189	422	1.09	1.22	
July	1,000	135	306	.79	.91	
August	1,230	109	247	.64	.74	
September	6,617	121	531	1.37	1.53	
October	785	145	206	.53	.61	
November	263	99	162	.42	.47	
December	237	73	127	.33	.38	

Monthly discharge of Roanoke River at Roanoke, Va., for 1896–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1904						
January	355	43	150	0.387	0.446	
February	550	103	229	.590	.636	
March	1,380	212	395	1.02	1.18	
April	355	115	202	.521	.581	
May	985	196	292	.753	.868	
June	1,960	181	417	1.07	1.19	
July	1,380	103	264	.680	.784	
August	2,390	140	453	1.17	1.35	
September	286	103	133	.343	.383	
October	103	82	91	.235	.271	
November	153	92	111	.286	.319	
December	181	92	118	.304	.350	
The year	2,390	43	238	.613	8.36	
1905						
January	800	74	213	.549	.633	
February	880	85	259	.668	.696	
March	2,390	224	620	1.60	1.84	
April	500	186	316	.814	.908	
May	3,877	152	802	2.07	2.39	
June	1,390	122	317	.817	.912	
July	8,170	152	1,190	3.07	3.54	
August	725	205	374	.964	1.11	
September	4,633	152	469	1.21	1.35	
October	278	122	157	.405	.467	
November	152	101	126	.325	.363	
December	3,310	122	425	1.10	1.27	
The year	8,170	74	439	1.13	15.48	
1906						
January	3,980	310	808	2.08	2.40	
February	590	186	299	.771	.80	
March	880	186	524	1.35	1.56	
April	960	244	459	1.18	1.32	
May	360	152	243	.626	.72	
June	360	96	161	.415	.46	
July 1–15	122	85	99	.255	.14	
1907						
May 7–18	1,320	251	494	1.27	1.18	B.
June	3,310	404	768	1.98	2.21	B.
July	539	178	244	.629	.73	B.
August	251	162	187	.482	.56	B.
September	6,550	132	462	1.19	1.33	B.
October	213	162	173	.446	.51	B.
November	1,370	162	384	.990	1.10	B.
December	1,620	251	632	1.63	1.88	B.

Monthly discharge of Roanoke River at Roanoke, Va., for 1896–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1908						
January	9,380	152	1,230	3.17	3.66	B.
February	655	152	448	1.15	1.24	B.
March	590	415	506	1.30	1.50	B.
April	2,260	224	494	1.27	1.42	B.
May	1,050	264	478	1.23	1.42	B.
June	1,600	179	421	1.09	1.22	B.
July	1,660	169	358	.923	1.06	C.
August	1,100	117	207	.534	.62	C.
September	1,660	134	262	.675	.75	C.
October	6,550	109	647	1.67	1.92	B.
November	1,140	287	459	1.18	1.32	B.
December	2,450	244	627	1.62	1.87	B.
The year	9,380	109	511	1.32	18.00	
1909						
January	1,720	376	838	2.16	2.49	A.
February	1,780	317	531	1.37	1.43	A.
March	896	279	542	1.40	1.61	A.
April	7,630	237	737	1.90	2.12	A.
May	6,480	279	1,210	3.12	3.60	A.
June	940	218	413	1.06	1.18	A.
July	690	110	210	.541	.62	A.
August	895	86	248	.639	.74	A.
September	351	86	128	.330	.37	A.
October	519	75	158	.407	.47	A.
November	123	86	103	.265	.30	B.
December	376	....	108	.278	.32	B.
The year	7,630	....	436	1.12	15.25	
1910						
January	770	60	250	0.644	0.74	B.
February	3,720	136	506	1.30	1.35	A.
March	1,490	151	361	.930	1.07	A.
April	488	136	242	.624	.70	A.
May	326	136	210	.541	.62	A.
June	7,970	123	1,190	3.07	3.42	B.
July	3,240	205	546	1.41	1.63	A.
August	224	122	163	.420	.48	A.
September	415	102	175	.451	.50	A.
October	500	96	158	.407	.47	A.
November	122	74	96.7	.249	.28	A.
December	360	85	139	.358	.41	B.
The year	7,970	60	334	.861	11.67	
1911						
January	1,900	166	512	1.32	1.52	A.
February	1,230	237	408	1.05	1.09	A.
March	1,780	200	659	1.70	1.96	A.
April	2,900	376	982	2.53	2.82	A.
May	403	151	217	.559	.64	A.
June	488	186	199	.513	.57	A.
July	1,030	86	191	.492	.57	A.
August	376	65	107	.276	.32	A.
September	237	82	110	.284	.32	A.
October	2,580	76	213	.549	.63	A.
November	550	110	212	.546	.61	A.
December	1,660	98	535	1.38	1.59	A.
The year	2,580	65	362	.933	12.64	

Monthly discharge of Roanoke River at Roanoke, Va., for 1896–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1912						
January	770	173	326	0.840	0.97	A.
February	3,180	206	622	1.60	1.73	A.
March	7,760	430	1,740	4.48	5.16	B.
April	2,640	242	640	1.65	1.84	A.
May	8,980	282	1,290	3.32	3.83	B.
June	1,230	206	316	.814	.91	A.
July	550	206	354	.912	1.05	A.
August	242	115	153	.394	.45	A.
September	2,020	115	266	.686	.77	A.
October	206	115	128	.330	.38	A.
November	550	115	189	.487	.54	A.
December	490	115	203	.523	.60	A.
The year	8,980	115	520	1.34	18.23	
1913						
January	1,130	143	271	0.698	0.80	A.
February	1,540	143	266	.686	.71	A.
March	7,900	242	965	2.49	2.87	B.
April	1,230	206	408	1.05	1.17	A.
May	5,200	143	604	1.56	1.80	B.
June	850	143	312	.804	.90	A.
July	1,440	102	281	.724	.83	A.
August	620	89	151	.389	.45	A.
September	300	50	106	.273	.30	D.
October	490	77	181	.466	.54	A.
November	1,660	115	277	.714	.80	A.
December	940	143	290	.747	.86	A.
The year	7,900	50	344	.887	12.03	
1914						
January	1,900	242	505	1.30	1.50	B.
February	2,520	282	900	2.32	2.42	B.
March	1,330	375	674	1.74	2.01	A.
April	1,330	282	558	1.44	1.61	A.
May	282	143	213	.549	.63	A.
June	143	89	110	.283	.31	A.
July	1,660	89	358	.923	1.06	A.
August	173	43	117	.302	.35	B.
September	173	65	95.2	.245	.27	A.
October	1,330	65	182	.469	.54	A.
November	490	89	145	.374	.42	A.
December	10,200	282	1,110	2.86	3.30	B.
The year	10,200	43	412	1.06	14.42	

NOTE.—Discharge interpolated for following periods: Aug. 25-28, 1897; Aug. 29-30, Oct. 29-30, and Dec. 18-20, 1898; Jan. 29-30, Feb. 14, and Apr. 3, 1899; Mar. 11, 1900; July 27-30, 1905. Discharge estimates approximate May 19-23, 1900, when bridge was being repaired. Mean discharge Dec. 21-31, 1909, estimated at 40 second-feet because of ice. No discharge measurements made during 1908, and accuracy of estimates at low stages for that year is somewhat doubtful.

ROANOKE RIVER AT RANDOLPH, VA.

Location.—At Southern Railway bridge, about five-eighths mile southwest of railroad station at Randolph; about one mile above Little Roanoke River, which enters from the left.

Drainage area.—3,080 square miles.

Gage.—Chain on upstream side of bridge. Datum raised about 2 feet October 13, 1902. During construction of new bridge in the summer of 1902 a temporary gage set by observer was used.

Records available.—August 27, 1900, to August 11, 1906. Gage heights since 1905 obtained and published by United States Weather Bureau, but no estimates of discharge were computed by United States Geological Survey.

Discharge measurements.—Made from railroad bridge.

Channel and control.—Control section below bridge changes during floods, and water flows in two flood channels through railroad embankment between bridge and station at Randolph; flow in main channel passes under bridge at an angle of about 73 degrees.

Extremes of discharge.—Maximum stage recorded: 32 feet, December 30, 1901; discharge approximately 75,100 second-feet. Minimum stage recorded: 2.5 feet, October 18, 1904; discharge, 590 second-feet.

Winter flow.—Discharge relation slightly affected by ice during severe winters.

Accuracy.—Records previous to November, 1902, may be subject to considerable error; after that date, good. During construction of new bridge, gage-height records approximate.

Discharge measurements of Roanoke River at Randolph, Va., for 1906–1911.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1906				1909			
June 8	Robert Follansbee..	4.20	1,440	Sept. 11..	Stevens and Thomas	[a]5.37	2,200
1907							
Feb. 22 ...	Warren E. Hall....	5.10	2,190	1911 July 29...	Mathers and Dean..	3.28	876

[a] Gage out of repair; gage height obtained by measurement from bench-mark on bridge.

Daily gage height, in feet, of Roanoke River at Randolph, Va., for 1906.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
1	10.3	11.5	5.75	9.85	4.65	5.6	5.95	8.5
2	8.65	10.1	5.75	7.95	4.8	5.4	5.65	6.55
3	6.6	7.5	5.6	7.15	4.9	5.4	5.3	6.4
4	12.9	6.2	5.75	6.75	4.8	5.4	5.05	6.85
5	23.6	6.2	5.85	6.45	4.65	5.6	4.85	7.1
6	19.8	6.35	5.9	6.4	4.85	5.5	4.75	7.3
7	7.65	6.3	6.15	6.15	5.15	5.45	4.75	7.1
8	6.7	6.25	6.0	5.95	5.7	5.15	4.55	6.9
9	6.75	6.25	5.85	6.35	6.05	5.25	4.55	6.7
10	6.9	7.05	5.75	7.5	5.9	5.35	4.85	7.4
11	6.85	6.85	5.85	8.95	5.55	5.1	5.25	7.5
12	6.95	6.65	5.85	9.15	5.5	5.15	5.8	....
13	7.15	6.25	5.85	8.65	5.0	5.05	5.9	....
14	7.25	5.7	5.75	7.3	5.05	4.95	5.65	....
15	6.75	6.05	5.65	8.25	4.9	5.2	5.45	....
16	6.55	5.85	5.65	8.2	4.85	5.2	5.25	....
17	6.35	5.65	5.85	7.5	4.65	5.25	4.75	....
18	6.3	5.45	8.85	7.35	4.75	5.35	4.45	....
19	5.85	5.35	7.7	7.35	4.65	5.65	4.25	....
20	5.4	5.35	13.0	7.4	4.65	5.15	4.4	....
21	5.85	5.25	11.0	7.0	4.45	7.2	5.05	....
22	5.85	5.35	9.1	6.75	4.45	9.35	5.55	....
23	5.65	5.15	7.75	6.45	4.2	6.95	6.5	....
24	5.75	4.95	7.05	6.45	4.1	5.1	6.15	....
25	5.6	4.95	6.8	6.3	3.9	7.75	5.3	....
26	5.8	4.85	6.75	5.95	4.1	7.4	4.6	....
27	6.05	5.15	6.75	5.65	4.45	6.65	4.55	....
28	10.6	5.35	7.15	5.6	5.75	6.35	4.25	....
29	11.55	....	7.35	5.25	8.9	6.65	4.5	....
30	12.4	....	8.75	5.0	8.3	6.25	7.45	....
31	12.5	....	15.6	....	6.55	....	7.75	....

NOTE.—Discharge relation probably unaffected by ice.

Daily discharge, in second-feet, of Roanoke River at Randolph, Va., for 1906.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
1	7,420	8,860	2,740	6,910	1,840	2,620	2,920	5,420
2	5,580	7,200	2,740	4,850	1,960	2,440	2,660	3,460
3	3,510	4,400	2,620	4,050	2,040	2,440	2,360	3,320
4	10,500	3,140	2,740	3,650	1,960	2,440	2,160	3,750
5	35,200	3,140	2,830	3,370	1,840	2,620	2,000	4,000
6	23,600	3,280	2,870	3,320	2,000	2,530	1,920	4,200
7	4,550	3,230	3,100	3,100	2,240	2,490	1,920	4,000
8	3,600	3,180	2,960	2,920	2,700	2,240	1,770	3,800
9	3,650	3,180	2,830	3,280	3,000	2,320	1,770	3,600
10	3,800	3,950	2,740	4,400	2,870	2,400	2,000	4,300
11	3,750	3,750	2,830	5,920	2,570	2,200	2,320	4,400
12	3,850	3,560	2,830	6,140	2,530	2,240	2,780	....
13	4,050	3,180	2,830	5,580	2,120	2,160	2,870	....
14	4,150	2,700	2,740	4,200	2,160	2,080	2,660	....
15	3,650	3,000	2,660	5,160	2,040	2,280	2,490	....
16	3,460	2,830	2,660	5,110	2,000	2,280	2,320	....
17	3,280	2,660	2,830	4,400	1,840	2,320	1,920	....
18	3,230	2,490	5,800	4,250	1,920	2,400	1,690	....
19	2,830	2,400	4,600	4,250	1,840	2,660	1,540	....
20	2,440	2,400	10,700	4,300	1,840	2,240	1,660	....

Daily discharge, in second-feet, of Roanoke River at Randolph, Va., for 1906—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
21	2,830	2,320	8,260	3,900	1,690	4,100	2,160	....
22	2,830	2,400	6,080	3,650	1,690	6,360	2,570	....
23	2,660	2,240	4,650	3,370	1,510	3,850	3,420	....
24	2,740	2,080	3,950	3,370	1,440	2,200	3,100	....
25	2,620	2,080	3,700	3,230	1,300	4,650	2,360	....
26	2,780	2,000	3,650	2,920	1,440	4,300	1,800	....
27	3,000	2,240	3,650	2,660	1,690	3,560	1,770	....
28	7,780	2,400	4,050	2,620	2,740	3,280	1,540	....
29	8,920	....	4,250	2,320	5,860	3,560	1,730	....
30	9,940	....	5,700	2,120	5,220	3,180	4,350	....
31	10,100	....	14,000	....	3,460	....	4,650	....

NOTE.—Discharge computed from a fairly well-defined rating curve.

Monthly discharge of Roanoke River at Randolph, Va., for 1900–1906.

[Drainage area, 3,080 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1900						
September	8,625	1,120	1,878	.61	.68	
October	17,900	1,350	2,597	.84	.97	
November	18,100	2,025	2,938	.96	1.07	
December	18,600	2,550	3,944	1.28	1.48	
1901						
January	35,980	2,550	5,362	1.74	2.01	
February	3,860	2,410	2,948	.96	1.02	
March	14,850	2,340	4,000	1.30	1.50	
April	36,910	3,580	9,620	3.13	3.49	
May	37,940	2,980	8,148	2.65	3.16	
June	9,750	3,140	4,759	1.55	1.73	
July	27,180	2,690	6,259	2.03	2.34	
August	44,380	2,620	13,185	4.29	4.94	
September	6,955	2,620	3,998	1.30	1.45	
October	6,725	2,795	3,346	1.09	1.26	
November	5,260	2,725	2,984	.97	1.08	
December	75,100	2,830	9,621	3.13	3.61	
The year	75,100	2,340	6,186	2.01	27.59	
1902						
January	26,200	2,800	5,388	1.75	2.02	
February	51,050	2,880	10,290	3.35	3.49	
March	40,500	3,600	8,616	2.80	3.23	
April	10,120	3,040	4,398	1.43	1.60	
May	4,960	2,400	3,250	1.06	1.22	
June	24,450	2,070	3,656	1.19	1.33	
July	3,440	1,580	2,149	.70	.81	
August	5,370	1,580	2,198	.71	.82	
September	2,720	1,535	1,844	.60	.67	
October	38,150	1,485	4,845	1.58	1.82	
November	8,600	1,370	2,551	.83	.92	
December	14,550	2,270	5,349	1.74	2.01	
The year	51,050	1,370	4,545	1.48	19.94	

Monthly discharge of Roanoke River at Randolph, Va., for 1900–1906—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1903						
January	23,850	2,590	6,123	1.99	2.29	
February	44,200	3,710	8,575	2.79	2.90	
March	44,550	3,915	11,010	3.58	4.13	
April	14,050	4,320	7,041	2.29	2.55	
May	4,500	2,590	3,370	1.10	1.27	
June	9,200	2,430	4,147	1.35	1.51	
July	4,950	1,500	2,445	.79	.91	
August	9,680	1,310	2,712	.88	1.01	
September	13,420	1,570	3,273	1.06	1.18	
October	4,410	1,500	2,191	.71	.82	
November	2,510	1,500	1,841	.60	.67	
December	2,430	1,570	1,940	.63	.73	
The year	44,550	1,310	4,556	1.48	19.97	
1904						
January	2,860	1,540	2,087	0.678	0.782	
February	7,810	1,620	3,667	1.19	1.28	
March	3,770	2,020	2,787	.906	1.04	
April	4,435	1,540	2,224	.723	.807	
May	5,720	1,540	2,939	.955	1.10	
June	9,750	2,265	3,397	1.10	1.23	
July	5,420	725	2,117	.688	.793	
August	6,760	1,305	2,899	.942	1.09	
September	3,770	725	1,801	.586	.654	
October	1,230	590	787	.256	.295	
November	2,435	725	889	.289	.322	
December	2,690	1,230	1,881	.612	.706	
The year	9,750	590	2,290	.744	10.10	
1905						
January	10,530	1,050	2,773	.901	1.04	
February 22–28	9,585	7,470	8,497	2.76	.718	
March	9,010	1,950	4,601	1.50	1.73	
April	5,380	1,555	2,576	.837	.934	
May	9,470	1,630	3,974	1.29	1.49	
June	9,470	1,260	2,891	.940	1.05	
July	28,960	2,508	6,485	2.11	2.43	
August	5,750	1,710	3,083	1.00	1.15	
September	23,940	1,030	3,213	1.04	1.16	
October	3,335	1,120	1,528	.497	.573	
November	1,518	1,155	1,292	.420	.469	
December	29,740	1,592	4,733	1.54	1.78	
1906						
January	35,200	2,440	6,200	2.01	2.32	B.
February	8,860	2,000	3,220	1.05	1.09	B.
March	14,000	2,620	4,210	1.37	1.58	B.
April	6,910	2,120	3,980	1.29	1.44	B.
May	5,860	1,300	2,300	.747	.86	B.
June	6,360	2,080	2,880	.935	1.04	B.
July	4,650	1,540	2,360	.766	.88	B.
August 1–11	5,420	3,320	4,020	1.31	.54	B.

NOTE.—Estimates of discharge for September, 1900, to October, 1902, may be considerably in error. River frozen Jan. 14-15, 1902, and Jan. 28-31, 1905; no correction made in estimates for any probable effect from freezing.

ROANOKE RIVER AT OLD GASTON, N. C.

Location.—At bridge of Roanoke Railway Co., at Old Gaston, 1¼ miles north of Thelma, about three-fourths mile below mouth of Indian Creek, and 2½ miles above mouth of Deep Creek.

Drainage area.—8,350 square miles.

Records available.—December 7, 1911, to December 31, 1914.

Gage.—Chain attached to outside of guard timber on downstream side of second span from right end of deck-plate girder railroad bridge of Roanoke Railway Co.; read once daily.

Discharge measurements.—Made from downstream side of bridge to which gage is attached; measuring section broken by 11 bridge piers.

Channel and control.—Channel fairly permanent; point of control, about 1 mile below gage, rock and probably permanent. Left bank overflows in extreme floods, but a fair determination can be made of the overflow discharge around the bridge.

Extremes of discharge.—Maximum stage recorded: 16.6 feet at 7 A. M., March 18, 1912; discharge, 210,000 second feet. Minimum stage recorded: 0.95 foot at 6 A. M., October 1, 1914; discharge, 790 second-feet.

Flood of 1877 highest known in this locality. No definite marks preserved at Old Gaston, but from authentic information regarding the crest height as observed in 1877 the approximate height has been determined as about 19 feet, referred to present gage datum. The corresponding discharge is about 275.000 second-feet. (See Plate IV.)

Winter flow.—A considerable thickness of ice sometimes forms at station, but the discharge relation is seldom affected thereby.

Regulation.—Persons engaged in the operation of power plants at Roanoke Rapids and Weldon have observed on Tuesday or Wednesday during periods of low water a trough probably due to the weekly shutdown of large power plants farther upstream.

Accuracy.—Station not very sensitive, as gage is about 1 mile from lower end of a pool approximately 3 miles long. Rating curve reliable and results excellent.

Coöperation.—Station maintained by United States Geological Survey in coöperation with Virginia Railway and Power Co.

Discharge measurements of Roanoke River at Old Gaston, N. C., in 1911–1914.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1911				1912			
Dec. 8	H. J. Jackson	1.95	3,590	Mar. 19	H. J. Jackson	11.68	89,300
				Mar. 25	do	6.53	30,300
1912				Aug. 25	L. J. Bevan [a]	1.42	1,940
Feb. 24	H. J. Jackson	6.81	31,300	Nov. 18	Jackson and Batchelder	2.06	3,900
Feb. 26	do	5.08	18,400				
Feb. 28	do	8.48	47,000	1914			
Mar. 2	do	4.09	12,400	Sept. 28	Mathers and Morgan	1.24	1,430
Mar. 17	do	15.00	169,000				

[a] Engineer with Vielé, Blackwell, and Buck.

Daily gage height, in feet, of Roanoke River at Old Gaston, N. C., for 1911–1914.

[R. A. Howell, observer.]

Day	Dec.	Day	Dec.	Day	Dec.
1911		1911		1911	
1	....	11	1.8	21	3.5
2	....	12	1.8	22	4.6
3	....	13	1.6	23	4.6
4	....	14	1.9	24	6.9
5	....	15	2.5	25	7.5
6	....	16	2.2	26	6.1
7	2.0	17	4.6	27	5.8
8	1.9	18	6.3	28	5.0
9	1.8	19	5.4	29	4.4
10	1.7	20	4.0	30	3.9
				31	3.5

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	3.4	5.4	5.6	10.45	4.05	2.45	3.75	1.65	1.4	1.95	1.7	1.75
2	3.9	4.4	4.3	5.6	3.85	2.55	3.75	1.9	1.25	1.95	1.6	1.75
3	3.8	3.4	3.75	4.85	3.45	2.45	4.75	1.5	1.15	1.75	1.7	1.75
4	3.6	3.4	3.5	4.75	3.15	2.55	3.75	1.5	1.15	1.75	1.65	1.65
5	3.5	2.5	3.25	4.35	2.9	2.25	3.2	1.45	.95	1.65	1.6	1.85
6	3.3	2.5	3.4	3.9	2.8	2.3	2.35	1.9	1.4	1.65	1.5	1.85
7	2.9	2.5	3.35	3.6	2.6	2.35	2.75	1.45	1.4	1.6	1.65	2.2
8	2.5	2.2	4.0	3.65	3.45	2.35	3.0	1.65	1.45	1.8	1.95	2.3
9	....	2.2	5.5	3.65	4.45	3.0	2.55	1.75	1.25	1.4	7.3	2.25
10	2.3	2.4	5.7	3.55	4.1	2.8	2.6	1.55	1.25	1.5	5.8	2.05
11	2.3	2.5	5.4	3.5	3.25	2.15	2.05	1.55	1.5	1.25	3.75	2.3
12	2.3	2.4	4.65	3.35	3.85	2.35	2.25	1.55	1.5	1.55	2.8	2.4
13	2.3	2.0	5.2	3.25	6.5	2.5	2.7	1.45	1.35	1.55	2.7	1.85
14	2.3	2.3	6.8	3.2	9.8	2.05	2.5	1.4	1.25	1.45	2.15	1.85
15	2.3	2.0	7.1	3.25	11.05	2.10	2.05	1.55	1.2	1.65	2.0	1.8
16	2.3	2.8	12.5	2.9	7.2	3.2	2.0	1.55	1.2	1.5	1.95	1.8
17	2.3	3.6	13.4	3.2	7.2	2.35	2.25	1.5	1.65	1.75	2.0	1.75
18	2.3	3.5	16.6	3.2	7.8	2.35	1.9	1.45	1.4	1.8	1.95	1.65
19	2.3	4.2	13.8	3.65	6.2	2.65	1.9	1.4	1.5	1.8	1.85	1.85
20	2.3	4.9	5.6	3.6	4.6	2.75	1.95	1.35	1.85	1.65	1.85	1.8
21	4.2	4.5	4.45	3.35	3.95	2.8	2.25	1.8	2.75	1.7	1.8	1.8
22	3.6	4.6	4.0	3.15	3.65	2.5	2.4	1.45	2.2	1.7	1.8	1.8
23	3.3	6.9	3.8	3.65	3.45	2.2	2.05	1.55	1.8	1.45	1.8	1.85
24	3.1	7.3	3.95	4.55	3.3	2.9	1.95	1.45	1.9	1.75	1.75	1.85
25	2.9	5.0	6.1	4.25	3.15	2.5	2.05	1.4	5.4	1.7	1.7	1.85
26	2.8	5.0	8.3	3.6	3.0	3.05	1.85	1.35	6.3	1.65	1.75	2.1
27	2.7	6.7	8.7	3.2	2.95	2.85	1.9	1.25	4.25	1.7	1.55	2.05
28	2.7	8.3	6.0	3.0	2.65	2.35	1.75	1.15	3.2	1.65	1.75	2.1
29	2.8	8.8	4.95	3.1	2.9	4.55	1.75	1.25	2.8	1.8	1.7	2.35
30	3.3	....	8.3	3.15	2.6	3.85	1.85	1.45	2.25	1.3	1.7	2.2
31	5.5	....	9.6	....	2.5	....	1.45	1.95	....	1.55	....	2.0
1913												
1	2.4	3.6	4.4	5.2	2.35	3.4	3.7	1.55	2.6	1.45	2.15	1.95
2	2.5	3.2	5.5	4.5	2.15	3.0	3.4	1.45	2.9	1.65	1.95	2.25
3	3.0	3.0	4.2	3.8	2.15	2.9	3.5	1.7	3.3	1.5	1.85	4.2
4	2.8	2.6	3.4	3.4	2.1	2.9	2.15	3.2	3.9	1.55	1.85	5.6
5	2.9	3.0	3.2	3.0	2.05	2.8	2.3	3.8	6.5	1.45	1.9	4.2
6	2.8	2.8	2.8	2.8	2.6	2.4	5.1	3.4	6.4	1.85	1.8	3.4
7	2.8	2.8	2.5	2.6	2.1	2.3	4.1	2.6	4.3	1.25	1.7	3.0
8	2.8	2.6	2.45	2.25	1.9	2.45	3.0	1.9	3.4	1.15	1.75	2.9
9	2.5	2.3	2.3	2.6	1.95	3.6	2.5	1.7	2.4	1.5	2.6	2.7
10	2.3	2.25	2.2	2.25	2.1	3.6	2.0	1.85	2.05	1.8	6.7	3.0

A. Flood of March, 1912. Horizontal line indicates height of crest of flood.

B. Medium stage. July, 1911. Lower line on bridge piers indicates level of water as shown in "A": upper line, height of crest of flood of March, 1912.

ROANOKE RIVER AT OLD GASTON, N. C.

Daily gage height, in feet, of Roanoke River at Old Gaston, N. C., for 1911–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	2.25	2.1	2.1	2.25	2.0	3.0	1.9	2.05	1.75	2.05	8.9	2.4
12	2.15	2.3	2.8	2.2	1.95	2.35	1.8	1.95	1.85	3.3	6.9	2.6
13	2.05	2.15	2.8	3.3	1.9	2.8	3.2	3.2	1.55	2.9	4.1	1.95
14	1.9	2.3	3.0	8.3	2.0	3.2	2.6	3.2	1.55	2.05	3.5	2.3
15	2.2	2.1	9.4	9.1	1.9	2.8	2.2	2.6	1.6	2.5	3.0	2.2
16	2.05	2.1	11.0	5.6	1.85	2.6	2.25	2.05	1.4	2.0	2.8	2.0
17	1.95	2.05	13.0	4.4	1.95	2.1	1.85	2.05	1.3	1.75	2.6	1.95
18	1.95	1.95	12.7	4.2	1.9	2.25	1.8	2.2	1.55	1.7	2.6	2.1
19	1.9	2.0	5.7	3.8	2.5	2.0	1.8	1.85	1.45	1.8	3.0	1.95
20	2.0	1.95	4.3	3.4	2.8	1.95	1.8	1.5	1.55	1.6	2.8	2.05
21	1.95	1.9	3.9	3.2	2.8	1.95	1.8	1.7	2.3	1.7	2.6	1.95
22	2.05	2.0	3.7	2.8	2.05	1.9	2.8	1.65	2.05	4.8	2.85	1.9
23	2.05	2.05	3.6	3.0	2.15	2.2	2.25	1.95	2.4	3.6	2.25	1.9
24	2.05	2.05	3.4	2.8	4.4	3.4	1.9	2.2	3.6	3.4	2.15	2.05
25	2.8	2.0	3.2	2.6	6.8	4.2	1.65	1.95	2.8	3.4	2.0	3.0
26	3.7	2.15	3.0	2.6	8.7	3.1	1.6	1.95	2.2	5.6	1.95	4.3
27	3.5	2.1	3.1	2.4	7.8	3.3	1.65	1.6	1.8	5.3	1.75	4.9
28	5.1	2.35	3.4	2.4	4.2	3.4	1.6	1.85	1.75	4.8	2.0	5.0
29	6.0	....	4.2	2.4	5.0	3.7	1.5	1.65	1.8	3.2	1.95	4.0
30	5.9	....	4.8	2.6	5.8	3.5	1.5	1.7	1.6	2.7	1.95	3.4
31	4.4	....	3.8	....	4.2	....	1.55	2.15	....	2.45	....	3.3
1914												
1	3.0	3.3	4.0	3.2	2.5	2.35	2.6	2.1	1.8	0.95	1.55	1.5
2	3.0	3.9	4.1	3.3	2.3	1.95	3.0	1.95	1.65	1.05	1.5	1.45
3	3.1	4.3	3.7	3.7	2.35	1.8	3.0	1.7	1.55	1.1	1.2	2.7
4	6.5	3.7	3.4	3.7	2.3	1.6	2.8	1.75	1.6	1.0	1.15	3.8
5	8.3	3.3	3.2	3.5	2.5	1.4	3.0	2.35	1.35	1.05	1.5	8.2
6	7.5	3.2	3.2	3.3	2.6	1.95	3.1	2.2	1.35	1.05	1.5	8.2
7	4.8	4.0	3.4	3.0	3.2	1.85	3.0	1.95	1.7	1.1	1.45	7.8
8	3.8	6.5	3.9	3.2	3.5	1.65	2.45	2.0	1.15	2.4	1.55	7.2
9	3.5	6.0	3.4	3.0	3.0	1.75	2.4	1.5	1.0	1.8	1.4	4.6
10	3.3	4.6	3.2	3.2	2.8	1.95	2.3	1.45	1.0	1.65	1.55	3.8
11	3.2	4.3	3.2	3.4	2.4	1.7	2.0	1.3	1.05	1.6	1.55	3.4
12	3.0	3.6	3.5	3.2	2.3	1.5	2.3	1.6	1.0	1.45	1.6	3.2
13	3.1	4.0	4.0	2.9	2.5	1.55	2.35	1.55	1.2	1.15	1.55	3.2
14	3.0	3.4	4.5	2.6	2.7	1.45	2.35	1.5	1.25	1.25	1.55	3.4
15	2.8	3.0	4.8	3.0	2.85	1.75	2.6	1.55	1.3	1.05	1.65	4.5
16	2.5	3.2	4.7	3.7	2.9	1.85	6.3	1.55	1.25	2.6	2.8	4.0
17	2.25	3.3	4.3	4.8	3.0	1.6	5.7	1.4	1.1	3.2	3.6	3.5
18	2.25	3.2	3.9	4.4	2.0	1.9	4.5	1.3	1.05	5.5	4.0	3.2
19	2.6	3.6	4.0	3.7	1.85	1.65	3.5	1.15	1.0	3.8	3.8	3.0
20	2.3	4.2	4.1	3.2	2.2	1.6	2.95	1.25	1.05	2.8	2.6	2.6
21	2.6	7.7	4.2	3.8	1.95	1.5	2.2	1.25	1.1	2.4	2.0	2.8
22	2.25	8.2	4.0	4.0	2.0	1.55	1.95	1.2	1.05	1.9	1.9	3.9
23	2.2	6.8	4.0	3.8	1.95	1.5	1.2	1.2	1.05	1.6	1.75	4.2
24	2.25	5.4	4.1	3.4	2.0	1.4	1.85	1.3	1.15	1.65	1.6	4.2
25	2.6	4.8	4.2	3.2	1.9	1.35	1.75	1.4	1.1	1.55	1.55	4.0
26	2.8	4.0	3.8	3.0	1.9	1.6	1.65	1.3	1.3	1.5	1.75	5.2
27	3.0	3.8	3.6	2.9	1.75	1.35	1.6	1.3	1.15	1.6	1.7	6.4
28	3.1	3.8	3.4	2.7	1.85	2.0	1.65	1.4	1.3	1.75	1.7	5.4
29	3.0	....	3.2	3.0	1.8	2.9	1.85	1.4	1.15	1.7	1.7	4.4
30	3.0	....	3.2	2.9	1.75	2.6	2.05	1.65	1.15	1.6	1.65	5.3
31	3.0	....	3.2	....	2.0	....	2.15	1.6	....	1.55	....	7.1

NOTE.—Discharge relation probably affected by ice Jan. 13-18, 1912.

Daily discharge, in second-feet, of Roanoke River at Old Gaston, N. C., for 1911–1914.

Day	Dec.	Day	Dec.	Day	Dec.
1911		1911		1911	
1	....	11	3,090	21	9,500
2	....	12	3,090	22	15,300
3	....	13	2,460	23	15,300
4	....	14	3,410	24	32,400
5	....	15	5,500	25	37,800
6	....	16	4,430	26	25,900
7	3,740	17	15,300	27	23,600
8	3,410	18	27,400	28	17,900
9	3,090	19	20,600	29	14,200
10	2,770	20	11,900	30	11,400
				31	9,500

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	9,060	20,600	22,100	68,700	12,200	5,320	10,700	2,620	1,880	3,580	2,770	2,930
2	11,400	14,200	13,600	22,100	11,200	5,680	10,700	3,410	1,500	3,580	2,460	2,930
3	10,900	9,060	10,700	16,900	9,280	5,320	16,200	2,160	1,250	2,930	2,770	2,930
4	9,960	9,060	9,500	16,200	8,000	5,680	10,700	2,160	1,250	2,930	2,620	2,620
5	9,500	5,500	8,420	13,900	7,010	4,600	8,210	2,020	790	2,620	2,460	3,250
6	8,630	5,500	9,060	11,400	6,620	4,780	4,960	3,410	1,880	2,620	2,160	3,350
7	7,010	5,500	8,840	9,960	5,870	4,960	6,430	2,020	1,880	2,460	2,620	4,430
8	5,500	4,430	11,900	10,200	9,280	4,960	7,400	2,620	2,020	3,090	3,580	4,780
9	5,140	4,430	21,400	10,200	14,400	7,400	5,680	2,930	1,500	1,880	36,000	4,600
10	4,780	5,140	22,800	9,730	12,500	6,620	5,870	2,310	1,500	2,160	23,600	3,910
11	4,780	5,500	20,600	9,500	8,420	4,260	3,910	2,310	2,160	1,500	10,700	4,780
12	4,780	5,140	15,600	8,840	11,200	4,960	4,600	2,310	2,160	2,310	6,620	5,140
13	4,600	3,740	19,200	8,420	29,000	5,500	6,240	2,020	1,750	2,310	6,240	3,250
14	4,400	4,780	31,500	8,210	60,800	3,910	5,500	1,880	1,500	2,020	4,260	3,250
15	4,200	3,740	34,200	8,420	78,000	4,080	3,910	2,310	1,370	2,620	3,740	3,090
16	4,100	6,620	106,000	7,010	35,100	8,210	3,740	2,310	1,370	2,160	3,580	3,090
17	4,000	9,960	127,000	8,210	35,100	4,960	4,600	2,160	2,620	2,930	3,740	2,930
18	4,400	9,500	210,000	8,210	40,600	4,960	3,410	2,020	1,880	3,090	3,580	2,620
19	4,780	13,000	137,000	10,200	26,600	6,060	3,410	1,880	2,160	3,090	3,250	3,250
20	4,780	17,200	22,100	9,960	15,300	6,430	3,580	1,750	3,250	2,620	3,250	3,090
21	13,000	14,700	14,400	8,840	11,700	6,620	4,600	1,620	6,430	2,770	3,090	3,090
22	9,960	15,300	11,900	8,000	10,200	5,500	5,140	2,020	4,430	2,770	3,090	3,090
23	8,630	32,400	10,900	10,200	9,280	4,430	3,910	2,310	3,090	2,020	3,090	3,250
24	7,800	36,000	11,700	15,000	8,630	7,010	3,580	2,020	3,410	2,930	2,930	3,250
25	7,010	17,900	25,900	13,300	8,000	5,500	3,910	1,880	20,600	2,770	2,770	3,250
26	6,620	17,900	45,400	9,960	7,400	7,600	3,250	1,750	27,400	2,620	2,930	4,080
27	6,240	30,700	49,300	8,210	7,200	6,820	3,410	1,500	13,300	2,770	2,810	3,910
28	6,240	45,400	25,100	7,400	6,060	4,960	2,930	1,250	8,210	2,620	2,930	4,080
29	6,620	50,300	17,500	7,800	7,010	15,000	2,930	1,500	6,620	3,090	2,770	4,960
30	8,630	....	45,400	8,000	5,870	11,200	3,250	2,020	4,600	1,620	2,770	4,430
31	21,400	....	58,600	....	5,500	....	2,020	3,580	....	2,310	....	3,740
1913												
1	5,140	9,960	14,200	19,200	4,960	9,060	10,400	2,310	5,870	2,020	4,260	3,580
2	5,500	8,210	21,400	14,700	4,260	7,400	9,060	2,020	7,010	2,620	3,580	4,600
3	7,400	7,400	13,000	10,900	4,260	7,010	9,500	2,770	8,630	2,160	3,250	13,000
4	6,620	5,870	9,060	9,060	4,080	7,010	4,260	8,210	11,400	2,310	3,250	22,100
5	7,010	7,400	8,210	7,400	3,910	6,620	4,780	10,900	29,000	2,020	3,410	13,000
6	6,620	6,620	6,620	6,620	5,870	5,140	18,500	9,060	28,200	1,750	3,090	9,060
7	6,620	6,620	5,500	5,870	4,080	4,780	12,500	5,870	13,600	1,500	2,770	7,400
8	6,620	5,870	5,320	4,600	3,410	5,320	7,400	3,410	9,060	1,250	2,930	7,010
9	5,500	4,780	4,780	5,870	3,580	9,960	5,500	2,770	5,140	2,160	5,870	6,240
10	4,780	4,600	4,430	4,600	4,080	9,960	3,740	3,250	3,910	3,090	30,700	7,400

Daily discharge, in second-feet, of Roanoke River at Old Gaston, N. C., for 1911–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
11	4,600	4,080	4,080	4,600	3,740	7,400	3,410	3,910	2,930	3,910	51,300	5,140
12	4,260	4,780	6,620	4,430	3,580	4,960	3,090	3,580	3,250	8,630	32,400	5,870
13	3,910	4,260	6,620	8,630	3,410	6,620	8,210	8,210	2,310	7,010	12,500	3,580
14	3,410	4,780	7,400	45,400	3,740	8,210	5,870	8,210	2,310	3,910	9,500	4,780
15	4,430	4,080	56,400	53,300	3,410	6,620	4,430	5,870	2,460	5,500	7,400	4,430
16	3,910	4,080	77,100	22,100	3,250	5,870	4,600	3,910	1,880	3,740	6,620	3,740
17	3,580	3,910	117,000	14,200	3,580	4,080	3,250	3,910	1,620	2,930	5,870	3,580
18	3,580	3,580	110,000	13,000	3,410	4,600	3,090	4,430	2,310	2,770	5,870	4,080
19	3,410	3,740	22,800	10,900	5,500	3,740	3,090	3,250	2,020	3,090	7,400	3,580
20	3,740	3,580	18,600	9,060	6,620	3,580	3,090	2,160	2,310	2,460	6,620	3,910
21	3,580	3,410	11,400	8,210	6,620	3,580	3,090	2,770	4,780	2,770	5,870	3,580
22	3,910	3,740	10,400	6,620	3,910	3,410	6,620	2,620	3,910	16,600	4,960	3,410
23	3,910	3,910	9,960	7,400	4,260	4,430	4,600	3,580	5,140	9,960	4,600	3,410
24	3,910	3,910	9,060	6,620	14,200	9,060	3,410	4,430	9,960	9,060	4,260	3,910
25	6,620	3,740	8,210	5,870	31,500	13,000	2,620	3,580	6,620	9,060	3,740	7,400
26	10,400	4,260	7,400	5,870	49,300	7,800	2,460	3,580	4,430	22,100	3,580	13,600
27	9,500	4,080	7,800	5,140	40,600	8,630	2,620	2,460	3,090	19,900	2,930	17,200
28	18,500	4,960	9,060	5,140	13,000	9,060	2,460	3,250	2,930	16,600	3,740	17,900
29	25,100	....	13,000	5,140	17,900	10,400	2,160	2,620	3,090	8,210	3,580	11,900
30	24,300	....	16,600	5,870	23,600	9,500	2,160	2,770	2,460	6,240	3,580	9,060
31	14,200	....	10,900	....	13,000	....	2,310	4,260	....	5,320	....	8,630
1914												
1	7,400	8,630	11,900	8,210	5,500	4,960	5,870	4,080	3,090	790	2,360	2,160
2	7,400	11,400	12,500	8,630	4,780	3,580	7,400	3,580	2,620	915	2,160	2,020
3	7,800	13,600	10,400	10,400	4,960	3,090	7,400	2,770	2,310	1,130	1,370	6,240
4	29,000	10,400	9,060	10,400	4,780	2,460	6,620	2,930	2,460	900	1,250	10,900
5	45,400	8,630	8,210	9,500	5,500	1,880	7,400	4,960	1,750	915	2,160	8,210
6	37,800	8,210	8,210	8,630	5,870	3,580	7,800	4,430	1,750	915	2,160	8,210
7	16,600	11,900	9,060	7,400	8,210	3,250	7,400	3,580	2,770	1,130	2,020	40,600
8	10,900	29,000	11,400	8,210	9,500	2,620	5,320	3,740	1,250	5,140	2,360	35,100
9	9,500	25,100	9,060	7,400	7,400	2,930	5,140	2,160	900	3,090	1,880	15,300
10	8,630	15,300	8,210	8,210	6,620	3,580	4,780	2,020	900	2,620	2,360	10,900
11	8,210	13,600	8,210	9,060	5,140	2,770	3,740	1,620	1,020	2,460	2,360	9,060
12	7,400	9,960	9,500	8,210	4,780	2,160	4,780	2,460	900	2,020	2,460	8,210
13	7,800	11,900	11,900	7,010	5,500	2,310	4,960	2,310	1,370	1,250	2,360	8,210
14	7,400	9,060	14,700	5,870	6,240	2,020	4,960	2,160	1,500	1,500	2,360	9,060
15	6,620	7,400	16,600	7,400	4,960	2,930	5,870	2,310	1,620	915	2,620	14,700
16	5,500	8,210	15,900	10,400	7,010	3,250	27,400	2,310	1,500	5,870	6,620	11,900
17	4,600	8,630	13,600	16,600	7,400	2,460	22,800	1,880	1,130	8,210	9,960	9,500
18	4,600	8,210	11,400	14,200	3,740	3,410	14,700	1,620	1,020	21,400	11,900	8,210
19	5,870	9,960	11,900	10,400	3,250	2,620	9,500	1,250	900	10,900	10,900	7,400
20	4,780	13,000	12,500	8,210	4,430	2,460	7,200	1,500	1,020	6,620	5,870	5,870
21	5,870	39,700	13,000	10,900	3,580	2,160	4,430	1,500	1,130	5,140	3,740	6,620
22	4,600	44,400	11,900	11,900	3,740	2,310	3,580	1,370	1,020	3,410	3,410	11,400
23	4,430	31,500	11,900	10,900	3,580	2,160	1,370	1,370	1,020	2,460	2,930	13,000
24	4,600	20,600	12,500	9,060	3,740	1,880	3,250	1,620	1,250	2,620	2,460	13,000
25	5,870	16,600	13,000	8,210	3,410	1,750	2,930	1,880	1,130	2,310	2,310	11,900
26	6,620	11,900	10,900	7,400	3,410	2,460	2,620	1,620	1,620	2,160	2,930	19,200
27	7,400	10,900	9,960	7,010	2,930	1,750	2,460	1,620	1,250	2,460	2,770	28,200
28	7,800	10,900	9,060	6,240	3,250	3,740	2,620	1,880	1,620	2,930	2,770	20,600
29	7,400	....	8,210	7,400	3,090	7,010	3,250	1,880	1,250	2,770	2,770	14,200
30	7,400	....	8,210	7,010	2,930	5,870	3,910	2,620	1,250	2,460	2,620	19,900
31	7,400	....	8,210	....	3,740	....	4,260	2,460	....	2,360	....	34,200

NOTE.—Daily discharge determined from a rating curve well defined below 33,300 second-feet and fairly well defined up to 181,000 second-feet. Above 194,000 second-feet the rating curve is assumed a tangent. Discharge Jan. 13-18, 1912, estimated because of ice. A measurement made in 1914 at a lower stage than any previous measurements indicated that the curve used for discharge estimates below 25,000 second-feet was not correct. Discharge estimates for 1911-12 have therefore been recomputed, and supersede those previously published in United States Geological Survey Water-Supply Papers 302 and 322.

Monthly discharge of Roanoke River at Old Gaston, N. C., for 1911–1914.

[Drainage area, 8,350 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1911						
December 7-31	37,800	2,460	12,900	1.54	1.43	A.
1912						
January	21,400	4,000	7,380	0.884	1.02	B.
February	50,300	3,740	14,600	1.75	1.89	A.
March	210,000	8,420	38,000	4.55	5.25	A.
April	68,700	7,010	12,400	1.49	1.66	A.
May	78,000	5,500	16,900	2.02	2.33	A.
June	15,000	3,910	6,110	.732	.82	A.
July	16,200	2,020	5,440	.651	.75	A.
August	3,580	1,250	2,200	.263	.30	A.
September	27,400	790	4,460	.534	.60	A.
October	3,580	1,500	2,610	.313	.36	A.
November	36,000	2,160	5,290	.634	.71	A.
December	5,140	2,620	3,590	.430	.50	A.
The year	210,000	790	9,920	1.19	16.19	
1913						
January	25,100	3,410	7,240	.867	1.00	A.
February	9,960	3,410	5,010	.600	.62	A.
March	117,000	4,080	20,300	2.43	2.80	A.
April	53,300	4,430	11,200	1.34	1.50	A.
May	49,300	3,250	9,700	1.16	1.34	A.
June	13,000	3,410	6,890	.825	.92	A.
July	18,500	2,160	5,230	.626	.72	A.
August	10,900	2,020	4,320	.517	.60	A.
September	29,000	1,620	6,390	.765	.85	A.
October	22,100	1,250	6,150	.737	.85	A.
November	51,300	2,770	8,310	.995	1.11	A.
December	22,100	3,410	7,620	.913	1.05	A.
The year	117,000	1,250	8,220	.984	13.36	
1914						
January	45,400	4,430	10,100	1.21	1.40	A.
February	44,400	7,400	15,300	1.83	1.91	A.
March	16,600	8,210	11,000	1.32	1.52	A.
April	16,600	5,870	9,010	1.08	1.20	A.
May	9,500	2,930	4,930	.590	.68	A.
June	7,010	1,750	2,980	.357	.40	A.
July	27,400	1,370	6,640	.795	.92	A.
August	4,960	1,250	2,370	.284	.33	A.
September	3,090	900	1,480	.177	.20	A.
October	21,400	790	3,540	.424	.49	A.
November	11,900	1,250	3,540	.424	.47	A.
December	40,600	2,020	13,700	1.64	1.89	A.
The year	45,400	790	7,010	.839	11.41	

NOTE.—Discharge estimates for 1911-12 supersede those previously published in U. S. Geological Survey Water-Supply Papers 302 and 322.

TINKER CREEK AT ROANOKE, VA.

Location.—At the Lynchburg Avenue bridge, about 1½ miles northeast of the center of Roanoke, and about 1 mile above Glade Creek, the nearest important tributary.

Drainage area.—70 square miles.

Records available.—July 16, 1907, to July 31, 1908.

Gage.—Chain gage installed April 27, 1908, on upstream side of bridge to replace original vertical staff on left abutment.

Discharge measurements.—Made from bridge.

Channel and control.—Both banks will overflow at high stages, but all water passes under bridge. Just below bridge a low temporary dam of loose rock forms the controlling section at medium stages. At very low stages there is a small rapid between bridge and dam.

Extremes of discharge.—Maximum stage recorded: 7.0 feet at 10 A. M., September 23, 1907; discharge not computed. Minimum stage recorded: 0.4 foot, August and September, 1907; discharge, 13 second-feet.

Winter flow.—Discharge relation not affected by ice during 1907-8.

Accuracy.—Records good for low and medium stages; rating curve not developed for high stages.

Coöperation.—Station maintained by United States Geological Survey in coöperation with United States Forest Service.

Discharge measurements of Tinker Creek at Roanoke, Va., in 1907.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
May 7	R. J. Taylor	1.23	168	July 20	R. G. Knight	.69	56
June 22	R. G. Knight	.86	90	July 23	do	.63	39

Daily gage height, in feet, of Tinker Creek at Roanoke, Va., for 1907–8.

[R. P. Vandergrift, observer.]

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907							1907						
1	......	0.55	0.5	0.6	0.5	0.85	16	0.7	0.5	0.6	0.6	0.6	1.65
2	......	.55	.5	.6	.9	.8	17	.7	.5	.5	.7	.6	1.2
3	......	.5	.5	.6	.85	.8	18	.7	.5	.55	.7	.85	1.05
4	......	.5	.5	.6	.65	.8	19	.7	.5	.55	.7	1.0	1.0
5	......	.4	.5	.6	.65	.75	20	.7	.5	.5	.65	.9	1.0
6	......	.4	.5	.6	.65	.75	21	.7	.5	.5	.6	.9	1.0
7	......	.4	.65	.7	.6	.75	22	.7	.55	.6	.6	.9	.9
8	......	.4	.5	.65	.6	.7	23	.6	.6	5.0	.6	1.75	1.9
9	......	.45	.55	.6	.6	.7	24	.6	.6	1.5	.55	2.0	1.5
10	......	.75	.4	.6	.6	1.05	25	.6	.6	.85	.55	1.0	1.2
11	......	.6	.65	.65	.6	1.0	26	.5	.5	.9	.55	1.0	1.0
12	......	.6	.65	.6	.55	.9	27	.5	.5	.95	.55	.9	1.0
13	......	.65	.65	.55	.6	.9	28	.6	.4	.95	.55	.9	1.0
14	......	.5	.7	.6	.6	1.5	29	.7	.4	.85	.55	.9	1.0
15	......	.5	.7	.6	.6	1.65	30	.6	.4	.75	.55	.9	1.25
							31	.5	.5	......	.6	......	1.05

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
1	1.15	0.75	1.05	1.55	0.8	0.8	0.8	......	......	......	......	......
2	1.05	.75	1.05	1.55	.8	.85	1.05	......	......	......	......	......
3	1.05	.95	1.05	1.4	.8	.9	.85	......	......	......	......	......
4	1.05	.95	1.05	1.25	.8	1.35	1.7	......	......	......	......	......
5	1.05	.95	1.05	1.05	.8	1.1	1.35	......	......	......	......	......
6	1.05	.95	1.3	1.05	.8	1.0	1.55	......	......	......	......	......
7	2.05	.95	1.2	1.05	1.4	1.0	1.4	......	......	......	......	......
8	2.05	.95	1.05	.95	1.25	.9	1.05	......	......	......	......	......
9	1.25	.95	1.05	.95	1.1	1.55	1.0	......	......	......	......	......
10	1.1	.95	1.05	.95	.9	1.1	1.0	......	......	......	......	......
11	1.05	.95	1.05	.95	.9	1.1	1.0	......	......	......	......	......
12	4.05	1.1	1.05	.85	.9	1.0	1.0	......	......	......	......	......
13	2.0	1.65	1.05	.85	.9	1.0	1.0	......	......	......	......	......
14	1.55	1.85	1.05	.85	.9	1.0	.9	......	......	......	......	......
15	1.25	2.5	.95	.85	.9	1.0	.9	......	......	......	......	......
16	1.05	1.55	.95	.85	.8	1.0	.6	......	......	......	......	......
17	1.05	1.35	.95	.85	.8	.9	.8	......	......	......	......	......
18	1.05	1.15	.95	.85	.8	.9	.8	......	......	......	......	......
19	1.05	1.15	.95	.85	.8	.9	.8	......	......	......	......	......
20	1.05	1.15	.85	.85	.8	.9	.8	......	......	......	......	......
21	1.05	1.05	.85	.85	.9	.9	.8	......	......	......	......	......
22	1.05	1.05	.85	.85	.9	.9	.8	......	......	......	......	......
23	.95	1.05	.95	.85	1.0	.9	.8	......	......	......	......	......
24	.95	1.05	1.15	.8	1.0	.9	1.0	......	......	......	......	......
25	.95	1.05	1.1	.75	.8	.8	1.0	......	......	......	......	......
26	.85	1.05	1.05	.75	.8	.8	1.0	......	......	......	......	......
27	.85	1.05	1.05	.78	.8	.8	1.45	......	......	......	......	......
28	.85	1.05	.95	.8	.8	.8	1.15	......	......	......	......	......
29	.85	1.05	.95	.8	.8	.8	1.0	......	......	......	......	......
30	.85	......	.95	.75	.8	.8	1.0	......	......	......	......	......
31	.8	......	1.05	......	.8	......	1.0	......	......	......	......	......

Daily discharge, in second-feet, of Tinker Creek at Roanoke, Va., for 1907–8.

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907							1907						
1	......	31	24	38	24	84	16	55	24	38	38	38	......
2	......	31	24	38	95	74	17	55	24	24	55	38	161
3	......	24	24	38	84	74	18	55	24	31	55	84	126
4	......	24	24	38	46	74	19	55	24	31	55	115	115
5	......	18	24	38	46	64	20	55	24	24	46	95	115
6	......	18	24	38	46	64	21	55	24	24	38	95	115
7	......	18	46	55	38	64	22	55	31	38	38	95	95
8	......	13	24	46	38	55	23	38	38	......	38	......	......
9	......	18	31	38	38	55	24	38	38	245	31	......	245
10	......	64	18	38	38	126	25	38	38	84	31	115	161
11	......	38	46	46	38	115	26	24	24	95	31	115	115
12	......	38	46	38	31	95	27	24	24	105	31	95	115
13	......	46	46	31	38	95	28	38	18	105	31	95	115
14	......	24	55	38	38	245	29	55	13	84	31	95	115
15	......	24	55	38	38	......	30	38	13	64	31	95	174
							31	24	24	......	38	......	120

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1908								1908							
1	147	64	126	......	74	74	74	16	126	......	105	84	74	115	38
2	126	64	126	......	74	84	126	17	126	201	105	84	74	95	74
3	126	105	126	215	74	95	84	18	126	149	105	84	74	95	74
4	126	105	126	174	74	201	......	19	126	149	105	84	74	95	74
5	126	105	126	126	74	137	201	20	126	149	84	84	74	95	74
6	126	105	137	126	74	115	......	21	126	126	84	84	95	95	74
7	......	105	161	126	215	115	215	22	126	126	84	84	95	95	74
8	......	105	126	105	174	95	126	23	105	126	105	84	115	95	74
9	174	105	126	105	137	......	115	24	105	126	147	74	115	95	115
10	137	105	126	105	95	137	115	25	105	126	137	64	74	74	115
11	126	105	126	105	95	137	115	26	84	126	126	64	74	74	115
12	......	137	126	84	95	115	115	27	84	126	126	70	74	74	230
13	......	......	126	84	95	115	115	28	84	126	105	74	74	74	149
14	......	......	126	84	95	115	95	29	84	126	105	74	74	74	115
15	174	......	105	84	95	115	95	30	84	......	105	64	74	74	115
								31	74	......	126	......	74	......	115

NOTE.—Daily discharges for 1907 and 1908 are based on a fairly well-defined rating curve. The discharge was greater than 250 second-feet for all missing days from July 16, 1907, to July 31, 1908.

BACK CREEK NEAR ROANOKE, VA.

Location.—At a footbridge half a mile below settlement of Red Hill, and about 7 miles south of Roanoke. Nearest tributary, Narrows Creek, enters a short distance below station.

Drainage area.—43 square miles.

Records available.—May 8, 1907, to July 31, 1908.

Gage.—Staff fastened to overhanging tree on right bank about 200 feet above footbridge.

Discharge measurements.—Made from the footbridge or by wading.

Channel and control.—Both banks clean and will overflow somewhat. Bed is composed of sand and gravel; practically permanent.

Extremes of discharge.—Maximum stage recorded: 6.9 feet, September 23, 1907; discharge not computed. Minimum stage recorded: 0.9 foot, September, 1907; discharge, 10 second-feet.

Winter flow.—Discharge relation not affected by ice during 1907-8.

Accuracy.—Results good for low and medium stages; rating curve not developed for high stages.

Coöperation.—Station maintained by United States Geological Survey in coöperation with United States Forest Service.

Discharge measurements of Back Creek near Roanoke, Va., in 1907–8.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1907				1907			
May 8	R. J. Taylor	1.50	97	July 20	R. G. Knight	1.16	34
June 21	R. G. Knight	1.36	64	July 23	do	1.08	25
				1908			
				Apr. 25	Follansbee and Barrows	1.32	54

Daily gage height, in feet, of Back Creek near Roanoke, Va., for 1907–8.

[W. P. Turner, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	4.4	1.3	1.0	0.9	1.4	1.4	1.5
2	......	......	......	......	......	2.5	1.3	1.0	.9	1.5	1.7	1.5
3	......	......	......	......	......	2.1	1.3	1.0	1.1	1.5	1.5	1.5
4	......	......	......	......	......	1.7	1.2	1.0	1.2	1.5	1.4	1.5
5	......	......	......	......	......	1.7	1.2	1.0	1.1	1.5	1.4	1.5
6	......	......	......	......	......	1.6	1.2	1.15	1.0	1.5	1.4	1.5
7	......	......	......	......	......	1.5	1.2	1.1	1.0	1.5	1.4	1.5
8	......	......	......	......	1.5	1.6	1.1	1.0	1.0	1.5	1.4	1.5
9	......	......	......	......	1.5	1.5	1.1	1.0	1.0	1.5	1.4	1.6
10	......	......	......	......	1.4	1.4	1.3	1.0	1.0	1.5	1.5	1.8
11	......	......	......	......	1.4	1.6	1.2	1.4	1.4	1.5	1.5	1.7
12	......	......	......	......	1.3	1.5	1.2	1.3	1.1	1.4	1.5	1.6
13	......	......	......	......	1.3	3.1	1.2	1.5	1.0	1.4	1.5	1.5
14	......	......	......	......	1.2	2.5	1.2	1.2	1.0	1.4	1.4	1.6
15	......	......	......	......	1.2	2.0	1.3	1.1	1.0	1.4	1.4	1.8
16	......	......	......	......	1.2	1.8	1.2	1.1	.9	1.4	1.4	1.9
17	......	......	......	......	1.2	1.6	1.4	1.1	.9	1.4	1.4	1.8
18	......	......	......	......	1.2	1.5	1.2	1.0	.9	1.4	1.9	1.7
19	......	......	......	......	1.1	1.4	1.2	1.0	.9	1.4	1.6	1.6
20	......	......	......	......	1.1	1.4	1.2	1.0	.9	1.4	1.5	1.6
21	......	......	......	......	1.1	1.35	1.1	1.0	1.0	1.4	1.7	1.6
22	......	......	......	......	1.1	1.3	1.1	1.5	1.2	1.4	1.6	1.6
23	......	......	......	......	1.1	1.3	1.1	1.2	6.9	1.4	1.7	3.85
24	......	......	......	......	1.1	1.3	1.1	1.1	2.5	1.4	2.5	2.5
25	......	......	......	......	1.2	1.7	1.0	1.0	1.9	1.4	2.0	2.2
26	......	......	......	......	1.1	1.5	1.0	1.0	1.6	1.4	1.8	1.8
27	......	......	......	......	1.1	1.4	1.0	1.0	1.5	1.5	1.6	1.7
28	......	......	......	......	1.1	1.3	1.0	1.0	1.5	1.5	1.6	1.6
29	......	......	......	......	1.1	1.7	1.1	1.0	1.5	1.4	1.5	1.7
30	......	......	......	......	1.1	1.4	1.1	1.0	1.4	1.4	1.5	2.2
31	......	......	......	......	1.2	....	1.0	1.0	....	1.4	....	1.8

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1908								1908							
1	1.7	1.5	1.6	2.0	1.2	1.1	1.3	16	2.0	2.2	1.4	1.3	1.3	1.3	1.0
2	1.7	1.7	1.5	1.9	1.2	1.0	1.3	17	1.9	2.0	1.4	1.3	1.2	1.3	1.0
3	1.7	1.7	1.5	1.7	1.2	1.1	1.5	18	1.9	1.9	1.4	1.3	1.2	1.2	1.0
4	1.7	1.7	1.5	1.6	1.2	2.5	1.3	19	1.8	1.9	1.4	1.2	1.3	1.2	1.0
5	1.7	1.6	1.7	1.5	1.1	1.5	1.8	20	1.8	1.7	1.5	1.2	1.4	1.2	1.0
6	1.7	1.6	1.7	1.5	1.1	1.4	1.6	21	1.8	1.7	1.5	1.2	1.4	1.2	1.0
7	3.3	1.7	1.7	1.5	1.9	1.3	1.5	22	1.7	1.7	1.5	1.2	1.4	1.2	1.0
8	2.2	1.7	1.6	1.5	1.5	1.3	1.5	23	1.7	1.7	1.6	1.2	1.4	1.2	1.3
9	2.0	1.7	1.6	1.4	1.4	1.9	1.4	24	1.7	1.6	1.5	1.2	1.3	1.1	1.2
10	1.9	1.7	1.6	1.4	1.3	1.4	1.3	25	1.7	1.6	1.5	1.3	1.3	1.1	1.1
11	1.7	1.6	1.5	1.4	1.2	1.3	1.3	26	1.7	1.8	1.5	1.3	1.2	1.35	1.6
12	4.5	2.0	1.6	1.4	1.2	1.8	1.2	27	1.7	1.7	1.4	1.2	1.2	1.2	1.3
13	3.0	2.4	1.5	1.3	1.2	1.5	1.2	28	1.6	1.6	1.4	1.1	1.2	1.1	1.2
14	2.5	2.5	1.5	1.3	1.2	1.4	1.1	29	1.5	1.6	1.4	1.2	1.1	1.1	1.5
15	2.2	4.0	1.4	1.4	1.2	1.4	1.1	30	1.5	......	1.4	1.4	1.1	1.0	1.2
								31	1.5	......	1.5	......	1.1	......	1.1

Daily discharge, in second-feet, of Back Creek near Roanoke, Va., for 1907–8.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	......	55	17	10	72	72	91
2	......	......	......	......	......	......	55	17	10	91	......	91
3	......	......	......	......	......	......	55	17	27	91	91	91
4	......	......	......	......	......	......	40	17	40	91	72	91
5	......	......	......	......	......	......	40	17	27	91	72	91
6	......	......	......	......	......	......	40	34	17	91	72	91
7	......	......	......	......	......	91	40	27	17	91	72	91
8	......	......	......	......	91	......	27	17	17	91	72	91
9	......	......	......	......	91	91	27	17	17	91	72	......
10	......	......	......	......	72	72	55	17	17	91	91	......
11	......	......	......	......	72	......	40	72	72	91	91	......
12	......	......	......	......	55	91	40	55	27	72	91	......
13	......	......	......	......	55	......	40	91	17	72	91	91
14	......	......	......	......	40	......	40	40	17	72	72	......
15	......	......	......	......	40	......	55	27	17	72	72	......
16	......	......	......	......	40	......	40	27	10	72	72	......
17	......	......	......	......	40	......	72	27	10	72	72	......
18	......	......	......	......	40	91	40	17	10	72	......	......
19	......	......	......	......	27	72	40	17	10	72	......	......
20	......	......	......	......	27	72	40	17	10	72	91	......
21	......	......	......	......	27	64	27	17	17	72	......	......
22	......	......	......	......	27	55	27	91	40	72	......	......
23	......	......	......	......	27	55	27	40	......	72	......	......
24	......	......	......	......	27	55	27	27	......	72	......	......
25	......	......	......	......	40	......	17	17	......	72	......	......
26	......	......	......	......	27	91	17	17	......	72	......	......
27	......	......	......	......	27	72	17	17	91	91	......	......
28	......	......	......	......	27	55	17	17	91	91	......	......
29	......	......	......	......	27	......	27	17	91	72	91	......
30	......	......	......	......	27	72	27	17	72	72	91	......
31	......		......		40		17	17		72		......

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1908							
1	......	91	......	......	40	27	55
2	......	......	91	......	40	17	55
3	......	......	91	......	40	27	91
4	......	......	91	......	40	......	55
5	......	......	......	91	27	91	......
6	......	......	......	91	27	72	......
7	......	......	......	91	......	55	91
8	......	......	......	91	91	55	91
9	......	......	......	72	72	......	72
10	......	......	......	72	55	72	55
11	......	......	91	72	40	55	55
12	......	......	......	72	40	......	40
13	......	......	91	55	40	91	40
14	......	......	91	55	40	72	27
15	......	......	72	72	40	72	27
16	......	......	72	55	55	55	17
17	......	......	72	55	40	55	17
18	......	......	72	55	40	40	17
19	......	......	72	40	55	40	17
20	......	......	91	40	72	40	17
21	......	......	91	40	72	40	17
22	......	......	91	40	72	40	17
23	......	......	......	40	72	40	55
24	......	......	91	40	55	27	40
25	......	......	91	55	55	27	27
26	......	......	91	55	40	64	......
27	......	......	72	40	40	40	55
28	......	......	72	27	40	27	40
29	91	......	72	40	27	27	91
30	91	......	72	72	27	17	40
31	91	......	91	......	27	......	27

NOTE.—Daily discharges for 1907 and 1908 are based on a well-defined rating curve. The discharge was greater than 100 second-feet for all missing days from May 18, 1907, to July 31, 1908.

DAN RIVER AT SOUTH BOSTON, VA.

Location.—At Norfolk & Western Railway bridge at South Boston. Banister River enters from the north about 7 miles below station.

Drainage area.—2,750 square miles.

Records available.—August 27, 1900, to May 5, 1907.

Gage.—Chain installed May 18, 1903, to replace wire gage previously used; read twice daily.

Discharge measurements.—Made from bridge.

Channel and control.—Left bank high; does not overflow. At high stages right bank overflows several hundred feet under a curved trestle approach to bridge. Bed of stream, sand and mud. Control section shifts during floods.

Extremes of discharge.—Maximum stage recorded: 25.2 feet at 4 P. M., December 31, 1901; discharge, 52,600 second-feet. Minimum stage observed: —0.10 foot at 10 A. M., October 11, 1904; discharge, 350 second-feet.

Winter flow.—Discharge relation not seriously affected by ice.

Accuracy.—Results good.

The following discharge measurement was made by Robert Follansbee:

June 9, 1906: Gage height, 2.13 feet; discharge, 1,850 second-feet.

Daily gage height, in feet, of Dan River at South Boston, Va., for 1906–7.

[John R. East, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	4.25	2.9	4.28	8.75	2.6	1.68	2.6	8.35	4.18	2.55	8.0	1.98
2	3.95	2.25	4.12	5.75	2.8	1.38	2.28	4.2	4.25	5.85	3.1	2.08
3	4.55	2.25	4.35	4.5	2.4	1.45	2.0	3.4	4.05	3.95	2.85	2.02
4	16.1	2.05	5.0	4.4	2.55	1.58	2.05	3.65	5.95	4.15	2.55	2.05
5	19.7	8.75	5.65	3.8	2.18	1.55	2.18	3.25	4.6	8.75	2.35	2.15
6	18.0	4.3	4.8	3.62	2.8	1.4	3.7	3.75	3.88	7.32	2.3	2.35
7	9.6	3.02	3.82	2.7	3.48	1.6	3.95	3.3	3.28	4.95	2.08	2.4
8	6.6	3.85	3.45	3.08	3.95	1.65	4.0	3.08	2.85	3.6	2.18	2.22
9	5.62	4.65	3.42	3.7	3.02	1.75	3.5	3.32	2.62	2.5	2.22	2.28
10	3.75	4.5	3.1	5.25	2.2	3.65	3.45	3.2	2.15	1.25	2.4	2.42
11	3.35	3.8	2.75	5.1	2.25	4.82	3.05	4.08	1.82	1.1	2.35	2.52
12	4.2	3.6	2.8	4.08	2.35	3.58	2.75	4.4	1.9	1.18	2.6	2.55
13	3.4	3.18	2.58	3.45	2.5	2.7	2.22	4.75	1.85	.95	2.55	2.62
14	5.0	3.18	2.9	3.88	2.18	2.12	2.28	5.45	2.15	....	2.3	2.72
15	6.35	2.9	3.65	4.8	1.78	1.78	2.95	6.48	2.02	....	2.52	2.6
16	4.3	2.6	5.15	5.7	1.85	1.8	3.08	7.72	2.8	....	2.42	2.65
17	5.35	2.95	4.65	4.5	1.82	3.1	3.18	10.8	2.3	2.75	2.55	2.75
18	4.45	2.9	3.5	3.58	1.92	3.92	3.7	15.6	2.2	2.8	2.75	2.8
19	4.1	2.7	4.05	3.18	2.05	3.42	4.05	18.5	2.25	4.65	2.8	2.62
20	3.65	2.55	4.0	2.88	1.92	5.78	4.95	17.0	2.48	7.12	3.05	2.52
21	3.05	2.65	5.95	2.68	1.85	4.7	6.75	13.7	3.85	12.75	3.18	2.42
22	3.85	3.5	5.9	2.58	1.98	3.6	10.0	8.9	4.42	8.4	3.2	2.35
23	7.9	2.32	4.05	2.7	1.85	3.9	12.5	7.68	3.9	6.5	2.55	2.22
24	12.3	2.35	3.25	2.58	1.42	3.65	10.3	6.08	3.88	5.05	2.55	2.3
25	8.35	2.5	4.3	2.52	1.8	3.42	8.0	4.85	3.22	4.6	2.35	2.18
26	6.9	2.55	3.8	2.55	2.35	3.35	7.75	4.08	3.15	4.12	2.22	2.12
27	6.0	2.75	4.25	2.42	3.0	6.6	6.65	4.18	2.5	3.9	2.15	2.02
28	8.85	4.12	4.9	2.32	3.5	3.5	7.48	4.18	1.9	3.8	2.1	2.02
29	9.4	....	4.6	2.88	3.45	2.55	5.35	4.65	2.12	3.85	2.05	2.12
30	7.68	....	8.3	2.85	1.7	2.42	3.7	4.95	1.98	3.92	1.92	4.75
31	6.3	....	11.3	....	1.55	....	3.4	4.02	....	3.75	....	10.7

Day	Jan.	Feb.	Mar.	Apr.	May	Day	Jan.	Feb.	Mar.	Apr.	May
1907						1907					
1	11.20	2.42	5.30	2.90	4.08	16	2.35	2.72	10.00	2.70	....
2	9.80	2.55	5.60	3.75	3.50	17	2.22	2.45	7.45	2.18	....
3	7.95	2.42	5.20	3.95	3.02	18	2.08	2.25	4.95	2.28	....
4	5.20	2.85	4.60	4.15	3.00	19	2.18	2.20	3.08	2.75	....
5	3.35	3.02	4.30	4.45	....	20	2.28	2.35	3.18	2.68	....
6	3.10	3.18	4.55	5.05	....	21	2.68	2.40	3.12	2.88	....
7	2.88	3.18	4.02	6.20	....	22	2.75	2.12	2.60	3.32	....
8	2.70	3.22	4.45	6.95	....	23	2.48	2.02	2.40	3.25	....
9	2.62	3.55	5.80	6.20	....	24	2.60	1.92	2.25	3.55	....
10	2.50	3.78	6.25	5.05	....	25	2.75	1.85	2.20	4.10	....
11	2.48	4.05	6.30	4.25	....	26	2.62	2.05	2.25	4.30	....
12	2.22	4.10	6.00	3.28	....	27	2.75	2.48	2.20	4.85	....
13	2.12	4.25	4.35	2.98	....	28	2.90	3.92	2.15	4.05	....
14	2.25	2.95	4.90	2.80	....	29	2.70	....	2.08	5.15	....
15	2.12	2.70	7.05	2.50	....	30	2.35	....	2.22	4.62	....
						31	2.15	....	2.28	....	....

Daily discharge, in second-feet, of Dan River at South Boston, Va., for 1906–7.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906												
1	3,695	2,585	3,721	3,118	2,345	1,619	2,840	2,950	3,640	2,300	2,660	1,850
2	3,442	2,068	3,585	5,030	2,107	1,385	2,090	3,650	3,700	5,120	2,750	1,980
3	3,954	2,068	3,781	3,910	2,186	1,440	1,870	2,990	3,530	3,440	2,540	1,890
4	19,340	1,910	4,349	3,824	2,305	1,541	1,910	3,190	5,220	3,610	2,300	1,910
5	30,180	3,276	4,988	3,317	2,012	1,518	2,010	2,870	4,000	3,120	2,150	1,990
6	24,600	3,738	4,172	3,086	2,107	1,401	3,230	3,280	3,380	6,560	2,110	2,150
7	9,160	2,681	3,334	2,425	3,054	1,557	3,440	2,910	2,890	4,300	1,930	2,190
8	5,838	3,359	3,029	2,730	3,442	1,596	3,480	2,730	2,540	3,150	2,010	2,040
9	4,910	4,041	3,005	3,234	2,681	1,674	3,070	2,920	2,360	2,260	2,040	2,090
10	3,276	3,910	2,746	4,578	2,028	3,193	3,030	2,830	1,990	1,280	2,190	2,200
11	2,948	3,317	2,465	4,438	2,068	4,190	2,710	3,550	1,730	1,170	2,150	2,280
12	3,658	3,152	2,107	3,551	2,147	3,136	2,460	3,820	1,790	1,230	2,340	2,300
13	2,989	2,811	2,329	3,029	2,265	2,425	2,040	4,130	1,750	1,050	2,300	2,360
14	4,349	2,811	2,585	3,888	2,012	1,965	2,090	4,750	1,990	1,760	2,110	2,440
15	5,596	2,585	3,193	4,172	1,697	1,697	2,620	5,720	1,890	1,760	2,280	2,340
16	3,738	2,345	4,483	4,984	1,752	1,713	2,730	6,970	2,110	1,760	2,200	2,380
17	4,664	2,625	4,041	3,910	1,729	2,746	2,810	10,800	2,110	2,460	2,300	2,460
18	3,867	2,585	3,070	3,135	1,807	3,417	3,230	18,300	2,080	2,500	2,460	2,500
19	3,568	2,425	3,526	2,811	1,910	3,005	3,530	26,200	2,070	4,040	2,500	2,360
20	3,193	2,305	3,484	2,569	1,807	5,058	4,300	21,600	2,250	6,350	2,710	2,280
21	2,705	2,385	5,217	2,409	1,752	4,084	5,980	15,000	3,360	18,600	2,810	2,200
22	3,359	3,070	5,170	2,329	1,854	3,152	9,700	8,300	3,840	7,720	2,830	2,150
23	7,165	2,123	3,526	2,425	1,752	3,400	13,300	6,930	3,400	5,740	2,300	2,040
24	12,975	2,147	2,867	2,329	1,417	3,193	10,100	5,340	2,970	4,390	2,300	2,110
25	7,660	2,265	3,738	2,281	1,713	3,005	7,280	4,220	2,840	4,000	2,150	2,010
26	6,134	2,305	3,317	2,305	2,147	2,948	7,000	3,550	2,790	3,580	2,040	1,960
27	5,264	2,465	3,695	2,202	2,665	5,838	5,890	3,640	2,260	3,400	1,990	1,890
28	8,235	3,585	4,260	2,123	3,070	3,070	6,720	3,640	1,790	3,320	1,950	1,890
29	8,905	....	3,997	2,569	3,029	2,305	4,660	4,040	1,970	3,360	1,910	1,960
30	6,929	....	7,605	2,545	1,635	2,202	3,230	4,300	1,850	3,420	1,810	4,130
31	5,548	....	11,525	....	1,518	....	2,990	3,500	....	3,280	....	10,700

Day	Jan.	Feb.	Mar.	Apr.	May	Day	Jan.	Feb.	Mar.	Apr.	May
1907						1907					
1	11,400	2,200	4,620	2,580	3,550	16	2,150	2,440	9,700	2,420	....
2	9,420	2,300	4,890	3,280	3,070	17	2,040	2,220	6,690	2,010	....
3	7,220	2,200	4,530	3,440	2,680	18	1,930	2,070	4,300	2,090	....
4	4,530	2,540	4,000	3,610	2,665	19	2,010	2,080	2,730	2,460	....
5	2,950	2,680	3,740	3,870	....	20	2,090	2,150	2,810	2,410	....
6	2,750	2,810	3,950	4,390	....	21	2,410	2,190	2,760	2,570	....
7	2,570	2,810	3,500	5,450	....	22	2,460	1,960	2,340	2,920	....
8	2,420	2,840	3,870	6,180	....	23	2,250	1,890	2,190	2,870	....
9	2,360	3,110	5,080	5,450	....	24	2,340	1,810	2,070	3,110	....
10	2,260	3,300	5,500	4,390	....	25	2,460	1,750	2,080	3,570	....
11	2,250	3,530	5,550	3,700	....	26	2,360	1,910	2,070	3,740	....
12	2,040	3,570	5,260	2,890	....	27	2,460	2,250	2,030	4,220	....
13	1,960	3,700	3,780	2,650	....	28	2,580	3,420	1,990	3,530	....
14	2,070	2,620	4,260	2,500	....	29	2,420	....	1,930	4,480	....
15	1,960	2,420	6,280	2,260	....	30	2,150	....	2,040	4,010	....
						31	1,990	....	2,090	....	....

NOTE.—Discharge computed from a fairly well-defined rating curve.

Monthly discharge of Dan River at South Boston, Va., for 1900–1907.

[Drainage area, 2,750 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1900						
September	7,605	700	1,430	0.52	0.58	
October	6,500	1,200	1,842	.67	.77	
November	4,600	1,360	1,804	.66	.74	
December	15,110	2,075	2,785	1.01	1.16	
1901						
January	21,960	1,860	3,387	1.23	1.42	
February	2,675	1,600	2,042	.74	.77	
March	25,000	1,600	3,504	1.27	1.46	
April	38,800	2,375	6,382	2.32	2.59	
May	45,600	2,300	7,297	2.65	3.06	
June	3,100	1,925	2,292	.83	.93	
July	44,200	2,150	6,132	2.23	2.58	
August	36,600	1,860	9,866	3.59	4.14	
September	5,100	2,150	2,902	1.06	1.18	
October	4,100	1,860	2,353	.86	.99	
November	3,730	1,730	2,032	.74	.83	
December	51,200	2,000	6,875	2.50	2.89	
The year	51,200	1,600	4,589	1.67	22.84	
1902						
January	30,000	2,675	4,738	1.72	1.98	
February	26,760	2,930	7,105	2.58	2.69	
March	26,120	3,730	7,269	2.64	3.04	
April	8,640	3,730	4,834	1.76	1.96	
May	4,450	3,100	3,876	1.41	1.63	
June	20,610	2,150	3,535	1.29	1.44	
July	3,775	1,075	1,713	.62	.71	
August	1,480	1,050	1,197	.44	.51	
September	3,415	900	1,545	.56	.62	
October	7,550	1,250	3,158	1.15	1.33	
November	2,525	1,420	1,842	.67	.75	
December	13,460	2,150	4,186	1.52	1.75	
The year	30,000	900	3,750	1.36	18.41	
1903						
January	27,160	2,665	5,628	2.05	2.36	
February	38,300	3,400	9,408	3.42	3.56	
March	42,570	3,653	9,545	3.47	4.00	
April	21,110	4,755	7,521	2.73	3.05	
May	8,780	2,465	3,869	1.41	1.63	
June	16,400	2,345	5,456	1.98	2.21	
July	15,500	1,479	4,190	1.52	1.75	
August 1-19 and 27	6,254	1,401	2,774	1.01	.751	
September 2, 14 and 18-30	7,715	1,362	2,090	.760	.424	
October	3,358	1,168	1,553	.565	.651	
November	3,884	1,862	1,811	.659	.735	
December	6,184	1,386	1,803	.656	.756	

Monthly discharge of Dan River at South Boston, Va., for 1900–1907—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1904						
January	2,665	750	1,663	0.605	0.697	
February	11,170	1,518	3,235	1.18	1.27	
March	9,290	1,596	2,847	1.04	1.20	
April	2,868	1,323	1,663	.605	.675	
May	7,275	1,091	1,999	.727	.838	
June	4,755	976	2,147	.781	.871	
July	5,548	824	1,877	.683	.788	
August	11,310	876	2,898	1.05	1.21	
September	10,750	1,029	2,248	.818	.913	
October	1,417	375	783	.285	.329	
November	2,569	608	1,233	.448	.500	
December	4,510	1,245	1,953	.710	.819	
The year	11,310	375	2,045	.744	10.11	
1905						
January	13,370	1,006	3,004	1.09	1.26	
February	18,270	1,052	4,563	1.66	1.73	
March	5,730	1,713	2,635	.958	1.10	
April	11,990	1,541	3,992	1.45	1.62	
May	17,160	1,729	4,845	1.76	2.03	
June	6,720	1,230	1,867	.679	.758	
July	10,400	1,440	3,927	1.43	1.65	
August	10,820	1,385	3,382	1.23	1.42	
September	6,214	1,076	1,709	.621	.693	
October	3,568	937	1,463	.532	.613	
November	1,635	976	1,337	.486	.542	
December	17,720	1,401	5,020	1.83	2.11	
The year	18,270	937	3,145	1.14	15.53	
1906						
January	30,200	2,700	7,160	2.60	3.00	
February	4,040	1,910	2,750	.999	1.04	
March	11,500	2,110	3,960	1.44	1.66	
April	8,120	2,120	3,320	1.21	1.35	
May	3,440	1,420	2,130	.774	.89	
June	5,840	1,380	2,650	.963	1.07	
July	13,300	1,870	4,250	1.55	1.79	
August	26,200	2,730	6,410	2.33	2.69	
September	5,220	1,730	2,670	.971	1.08	
October	13,600	1,050	3,870	1.41	1.63	
November	2,830	1,810	2,270	.825	.92	
December	10,700	1,850	2,480	.902	1.04	
The year	30,200	1,050	3,660	1.33	18.16	
1907						
January	11,400	1,930	3,040	1.11	1.28	B.
February	3,700	1,750	2,530	.920	.96	B.
March	9,700	1,930	3,830	1.39	1.60	B.
April	6,180	2,010	3,430	1.25	1.40	B.

NOTE.—Estimates for 1906 are good.

NEW RIVER BASIN.

SOUTH FORK OF NEW RIVER NEAR CRUMPLER, N. C.

Location.—About 1.6 miles above confluence of North and South forks of New River and about 4 miles from Crumpler.

Drainage area.—325 square miles.

Records available.—August 12, 1908, to December 31, 1914.

Gage.—Chain attached to trees on left bank about one-fourth mile above a ford.

Discharge measurements.—Made from a boat at a section about one-half mile below gage, or by wading at a section about 500 feet below.

Channel and control.—Practically permanent.

Extremes of stage.—Maximum stage observed: 7.1 feet at 7 A. M., October 24, 1908. Minimum stage observed: 0.87 foot, August 22-25, 1911.

Winter flow.—Discharge relation rarely affected by ice.

Accuracy.—Gage-height record very reliable.

Data insufficient for estimating discharge.

Discharge measurements of South Fork of New River near Crumpler, N. C., in 1908–1914.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
1908 Aug. 12	O'Neill and Chapman	1.48	458
1909 June 18	H. J. Jackson	2.02	1,060
1910 Nov. 1	C. T. Bailey	1.33	420
1911 July 24	Horton and Bailey	.94	232
1913 Dec. 16	Peterson and Walters	1.31	387
1914 Oct. 11	Mathers and Morgan	1.00	214
Oct. 12	do	.98	217

Daily gage height, in feet, of South Fork of New River near Crumpler, N. C., for 1908–1914.

[J. J. Garvey, observer.]

Day	Aug.	Sept.	Oct.	Nov.	Dec.	Day	Aug.	Sept.	Oct.	Nov.	Dec.
1908						1908					
1	....	1.73	1.46	2.27	1.69	16	1.62	1.50	1.53	1.72	1.66
2	....	1.72	1.40	2.16	1.77	17	1.61	1.48	1.49	1.70	1.64
3	....	1.68	1.40	2.08	1.64	18	1.62	1.48	1.38	1.76	1.65
4	....	1.66	1.39	2.02	1.57	19	1.52	1.46	1.38	1.78	1.65
5	....	1.68	1.38	1.96	1.57	20	1.55	1.44	1.38	1.78	1.68
6	....	1.82	1.38	1.86	1.57	21	1.56	1.44	1.38	1.68	1.58
7	....	1.85	1.38	1.78	2.42	22	1.80	1.43	1.48	1.68	1.65
8	....	1.96	1.36	1.78	2.37	23	1.78	1.43	3.93	1.68	1.85
9	....	1.76	1.51	1.78	1.97	24	2.00	1.42	6.23	1.66	1.73
10	....	1.64	2.73	1.75	1.78	25	2.60	1.42	3.08	1.68	1.76
11	....	1.58	2.18	1.83	1.71	26	3.88	1.40	2.46	1.68	1.95
12	1.48	1.58	1.73	1.78	1.86	27	2.62	1.40	2.23	1.68	1.84
13	1.47	1.53	1.64	1.73	1.81	28	2.23	1.73	2.32	1.64	1.76
14	1.49	1.50	1.56	1.74	1.73	29	2.10	1.68	3.03	1.57	1.83
15	1.51	1.48	1.55	1.75	1.69	30	1.96	1.58	2.93	1.57	1.85
						31	1.82	....	2.44	....	2.15

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	2.12	1.55	1.89	1.82	2.50	2.08	2.12	1.80	1.31	1.30	1.29	1.18
2	1.93	2.02	1.84	1.74	2.12	2.00	2.12	1.92	1.29	1.30	1.28	1.18
3	1.83	1.91	1.85	1.81	1.82	2.22	1.86	1.97	1.26	1.30	1.28	1.21
4	1.82	1.80	1.88	1.74	1.76	3.92	1.82	1.78	1.32	1.32	1.27	1.21
5	2.42	1.78	1.80	1.72	1.73	2.92	1.78	1.72	1.40	1.32	1.27	1.21
6	2.49	1.80	1.87	1.66	1.70	2.64	1.75	1.69	1.39	1.34	1.27	1.20
7	2.05	1.67	2.05	1.68	1.66	2.28	2.06	1.61	1.32	1.30	1.27	1.53
8	1.95	1.60	1.95	1.70	1.66	2.15	1.96	1.59	1.30	1.30	1.27	1.74
9	1.87	1.65	1.87	1.74	1.64	2.38	1.86	1.52	1.34	1.30	1.27	1.56
10	1.83	2.29	2.06	1.67	3.61	2.15	1.84	1.50	1.45	1.28	1.50	1.89
11	1.78	2.17	2.07	1.60	2.87	2.04	1.77	1.50	1.40	2.33	1.45	1.82
12	1.76	1.87	1.91	1.55	2.36	2.42	1.72	1.58	1.34	2.57	1.35	1.46
13	1.72	1.77	1.87	2.57	2.04	2.04	1.70	1.52	1.30	1.76	1.30	2.02
14	1.71	1.71	1.87	3.34	1.95	2.02	1.69	1.48	1.26	1.60	1.28	2.42
15	1.77	1.78	1.86	2.42	1.82	1.96	1.67	1.65	1.25	1.66	1.27	1.75
16	1.97	2.43	1.77	2.12	1.76	1.92	1.60	2.08	1.47	1.68	1.27	1.66
17	2.25	2.31	1.72	1.96	1.80	2.35	1.56	1.86	1.60	1.51	1.29	1.68
18	2.01	2.01	1.72	1.88	1.77	2.06	1.52	1.68	1.62	1.48	1.28	1.44
19	1.89	2.01	1.69	1.86	1.68	1.92	1.52	1.60	1.46	1.42	1.26	1.39
20	1.81	2.83	1.67	1.79	2.40	1.87	1.50	1.49	1.43	1.38	1.28	1.38
21	1.77	2.19	1.78	1.76	6.54	1.86	1.48	1.46	1.42	1.38	1.28	1.36
22	1.73	2.09	1.90	1.75	3.88	1.84	1.50	1.43	1.72	1.87	1.22	1.41
23	1.69	2.05	1.73	1.76	2.94	1.88	1.51	1.41	1.96	1.37	1.34	1.30
24	1.67	2.19	1.70	1.74	2.62	1.88	1.54	1.38	1.72	1.38	1.28	1.31
25	1.67	2.38	2.11	1.69	2.48	1.89	1.47	1.36	1.66	1.40	1.25	1.51
26	1.72	2.17	2.16	1.68	2.44	1.94	1.47	1.34	1.47	1.33	1.24	1.51
27	1.77	2.03	1.94	1.66	2.78	1.97	1.68	1.36	1.44	1.32	1.20	1.28
28	1.65	1.94	2.14	1.66	2.34	1.84	1.90	1.34	1.34	1.30	1.18	1.54
29	1.67	....	2.26	1.70	2.22	2.10	1.84	1.32	1.33	1.32	1.18	2.26
30	1.65	....	1.96	1.81	2.15	2.00	1.56	1.33	1.33	1.32	1.18	2.10
31	1.65	....	1.90	....	2.08	....	1.64	1.32	....	1.30	....	1.96

Daily gage height, in feet, of South Fork of New River near Crumpler, N. C., for 1908-1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
1	2.10	1.53	2.12	1.28	1.28	1.18	1.43	1.80	3.38	1.40	1.33	1.22
2	2.09	1.37	2.14	1.30	1.24	1.17	1.42	1.32	2.32	1.35	1.33	1.45
3	1.80	1.50	1.91	1.33	1.22	1.15	1.38	1.30	1.86	1.30	1.34	1.34
4	1.67	1.44	1.75	1.30	1.30	1.14	1.60	1.46	1.76	1.30	1.30	1.42
5	1.58	1.56	1.68	1.76	1.18	1.28	1.92	1.32	1.76	1.32	1.30	1.44
6	1.44	1.52	1.68	1.22	1.15	1.46	1.75	1.26	1.77	1.68	1.30	2.07
7	2.20	1.28	1.64	1.21	1.23	1.38	1.78	1.28	1.59	2.82	1.30	1.98
8	1.97	1.41	1.54	1.21	1.66	1.22	1.69	1.30	1.50	2.82	1.28	1.64
9	1.76	1.38	1.50	1.20	1.80	1.26	1.64	1.30	1.49	2.52	1.26	1.54
10	1.74	1.32	1.50	1.20	1.57	1.55	1.60	1.32	1.44	2.04	1.25	1.56
11	1.52	1.46	1.52	1.20	1.43	1.40	1.56	1.22	1.41	1.79	1.24	1.34
12	1.53	1.26	1.51	1.26	1.34	2.96	2.12	1.15	1.48	1.68	1.24	1.52
13	1.48	1.42	1.46	1.48	1.40	2.56	1.78	1.20	1.42	1.62	1.24	1.30
14	1.46	1.66	1.48	1.38	1.36	2.52	1.64	1.20	1.39	1.54	1.30	1.16
15	1.39	1.74	1.42	1.33	1.30	2.74	1.54	1.22	1.38	1.50	1.28	1.36
16	1.42	1.65	1.39	1.44	1.30	2.18	1.46	1.22	1.35	1.48	1.28	1.32
17	1.32	1.95	1.40	1.48	1.30	1.92	1.96	1.20	1.30	1.44	1.20	1.27
18	1.40	2.96	1.38	1.48	1.34	1.79	1.78	1.17	1.28	1.42	1.23	1.38
19	1.38	2.06	1.38	1.42	1.32	1.68	1.56	1.20	1.26	1.48	1.20	1.43
20	1.35	1.88	1.38	1.36	1.31	1.57	1.44	1.20	1.25	1.74	1.20	1.34
21	1.88	1.79	1.43	1.34	1.33	1.60	1.41	1.24	1.26	1.70	1.19	1.23
22	1.94	1.76	1.30	1.32	1.56	1.63	1.38	1.34	1.22	1.50	1.20	1.16
23	1.66	1.70	1.34	1.28	1.34	1.52	1.36	1.30	1.20	1.45	1.20	1.42
24	1.48	1.64	1.32	1.33	1.42	1.62	1.32	1.28	1.20	1.35	1.20	1.70
25	1.52	1.58	1.31	1.36	1.60	1.73	1.33	1.22	1.30	1.32	1.28	1.54
26	1.40	1.48	1.31	1.47	1.61	1.69	1.32	1.26	1.64	1.34	1.24	1.51
27	1.46	1.46	1.32	1.44	1.44	1.54	1.30	1.30	1.50	1.33	1.23	1.38
28	1.42	1.94	1.31	1.38	1.33	1.50	1.38	1.23	1.64	1.38	1.30	1.38
29	1.36	....	1.30	1.34	1.30	1.56	1.46	1.18	1.42	1.40	1.28	1.44
30	1.36	....	1.31	1.31	1.22	1.54	1.39	1.30	1.44	1.34	1.24	1.63
31	1.38	....	1.28	....	1.20	....	1.32	2.10	....	1.33	....	1.60
1911												
1	1.73	1.40	1.29	1.55	1.72	1.40	1.03	1.14	1.87	1.04	1.20	1.26
2	2.05	1.39	1.30	1.52	1.70	1.39	1.00	1.02	1.47	1.07	1.18	1.26
3	2.48	1.38	1.29	1.48	1.61	1.36	1.00	1.29	1.36	1.10	1.15	1.28
4	2.61	1.38	1.27	1.56	1.58	1.32	.98	1.47	1.20	1.14	1.14	1.21
5	2.07	1.38	1.24	2.62	1.54	1.32	1.16	1.39	1.12	1.20	1.14	1.18
6	1.83	1.36	1.52	2.70	1.52	1.42	1.26	1.44	1.15	1.14	1.84	1.22
7	1.69	1.38	2.02	2.18	1.48	1.40	1.16	1.42	1.16	1.08	1.66	1.25
8	1.62	1.48	2.02	2.28	1.46	1.42	1.42	1.26	1.10	1.08	1.54	1.21
9	1.50	1.82	2.26	2.10	1.50	1.33	1.26	1.24	1.08	1.06	1.50	1.19
10	1.42	1.84	2.04	1.93	1.48	1.28	1.22	1.06	1.18	1.10	1.48	1.17
11	1.48	1.68	1.84	1.78	1.46	1.28	1.22	1.00	1.20	1.20	1.40	1.22
12	1.48	1.56	1.76	1.91	1.46	1.26	1.16	.96	1.26	1.26	1.38	1.24
13	1.42	1.52	1.60	2.46	1.54	1.22	1.16	.98	1.14	1.18	1.54	1.25
14	1.42	1.50	1.58	2.88	1.72	1.20	1.12	1.09	1.04	1.10	1.50	1.24
15	1.41	1.45	1.54	2.52	1.62	1.16	1.40	1.13	1.02	1.16	1.44	1.32
16	1.36	1.44	1.46	2.36	1.50	1.12	1.17	1.00	1.00	1.04	1.38	1.56
17	1.31	1.40	1.42	2.11	1.42	1.12	1.65	.97	1.00	1.54	1.36	1.68
18	1.40	1.38	1.42	1.96	1.40	1.12	1.05	.96	1.00	3.71	1.38	1.48
19	1.36	1.37	1.45	2.00	1.40	1.15	1.00	.96	.99	2.29	1.41	1.36
20	1.36	1.45	1.50	2.09	1.40	1.26	.98	.96	.98	1.81	1.38	1.32
21	1.37	1.41	1.46	1.94	1.40	1.20	1.06	.92	2.29	1.56	1.36	1.54
22	1.44	1.38	1.40	1.84	1.89	1.18	1.02	.87	1.89	1.52	1.32	2.09
23	1.49	1.34	1.41	1.76	1.40	1.14	.97	.87	1.63	1.54	1.30	2.35
24	1.44	1.28	1.36	1.71	1.40	1.20	.96	.87	1.49	1.48	1.34	2.08
25	1.39	1.28	1.36	1.68	1.36	1.20	.95	.87	1.42	1.36	1.32	1.96

Daily gage height, in feet, of South Fork of New River near Crumpler, N. C., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
26	1.38	1.28	1.88	1.66	1.82	1.14	.91	.92	1.32	1.28	1.30	1.80
27	1.36	1.30	1.96	1.61	1.30	1.32	.86	1.26	1.26	1.29	1.30	1.83
28	1.34	1.29	1.88	1.60	1.30	1.13	.88	1.18	1.17	1.28	1.30	1.76
29	1.34	....	1.70	1.62	1.30	1.11	.89	1.35	1.11	1.26	1.30	1.66
30	1.54	....	1.61	1.67	1.28	1.10	.90	1.60	1.08	1.23	1.29	1.54
31	1.52	....	1.59	....	1.32	....	.92	1.94	....	1.21	....	1.71
1912												
1	1.8	1.48	1.65	2.0	1.7	1.48	1.40	1.48	1.10	1.35	1.17	1.28
2	1.7	1.42	1.6	2.25	1.65	1.55	1.42	1.40	1.10	1.31	1.20	1.30
3	1.55	1.44	1.65	2.15	1.6	1.6	1.55	1.36	1.10	1.28	1.18	1.30
4	1.43	1.34	1.6	1.95	1.55	1.65	1.48	1.40	1.09	1.24	1.16	1.28
5	1.38	1.36	1.65	1.85	1.6	1.5	1.6	1.42	1.06	1.22	1.15	1.32
6	1.30	1.7	1.7	1.8	1.65	1.65	1.85	1.40	1.12	1.20	1.14	1.38
7	2.05	1.65	1.7	1.8	1.6	1.7	1.65	1.34	1.23	1.20	1.95	1.44
8	2.0	1.75	1.8	1.8	1.55	1.6	1.5	1.30	1.48	1.18	2.25	1.35
9	2.1	1.6	1.85	1.75	1.49	1.5	1.48	1.46	1.39	1.18	1.65	1.28
10	2.0	1.55	1.75	1.7	1.47	1.44	1.5	1.48	1.23	1.15	1.45	1.25
11	2.0	1.6	1.7	1.65	1.5	1.41	1.55	1.44	1.08	1.14	1.36	1.21
12	1.9	1.46	1.75	1.65	2.7	1.39	2.0	1.34	1.10	1.14	1.32	1.18
13	1.8	1.55	2.0	1.65	2.5	1.38	1.75	1.30	1.22	1.14	1.30	1.31
14	1.65	1.49	2.0	1.6	2.05	1.55	1.7	1.28	1.32	1.29	1.89	1.28
15	1.75	1.36	3.0	1.6	1.9	1.7	1.7	1.28	1.34	1.40	1.34	1.22
16	1.75	1.47	3.1	1.6	2.2	1.75	1.55	1.32	1.30	1.36	1.30	1.34
17	1.8	1.55	2.6	1.6	2.4	1.55	1.55	1.28	1.28	1.26	1.26	1.24
18	1.95	1.48	2.15	1.7	2.05	1.46	1.6	1.28	1.22	1.18	1.22	1.20
19	2.15	1.38	2.0	1.55	1.85	1.35	1.9	1.27	1.19	1.22	1.21	1.22
20	2.15	1.41	1.9	1.55	1.75	1.30	2.15	1.34	1.26	1.25	1.20	1.21
21	2.05	1.85	1.8	1.5	1.7	1.30	1.95	1.36	1.18	1.24	1.18	1.19
22	1.9	2.9	1.75	1.75	1.65	1.30	1.8	1.29	1.13	1.30	1.18	1.19
23	1.8	1.95	1.7	1.8	1.6	1.33	1.7	1.24	2.05	1.37	1.18	1.24
24	1.8	1.85	2.0	1.7	1.6	1.32	1.6	1.18	2.3	1.34	1.18	1.25
25	1.7	1.8	2.1	1.6	1.55	1.95	1.6	1.17	1.7	1.26	1.18	1.20
26	1.5	1.9	1.9	1.55	1.55	1.65	1.6	1.17	1.5	1.20	1.18	1.38
27	1.44	2.15	1.8	1.75	1.5	1.55	1.5	1.17	1.7	1.18	1.14	1.5
28	1.30	2.0	1.75	1.7	1.5	1.5	1.43	1.14	1.6	1.15	1.24	1.38
29	1.49	1.85	2.7	1.7	1.8	1.42	1.4	1.14	1.5	1.15	1.42	1.40
30	1.75	....	2.5	1.75	1.6	1.5	1.85	1.12	1.37	1.15	1.37	1.7
31	1.65	....	2.1	....	1.55	....	1.65	1.11	....	1.14	....	1.7
1913												
1	1.5	1.45	1.8	2.1	1.7	1.81	1.38	1.28	1.20	1.55	1.46	1.75
2	1.30	1.41	1.65	2.0	1.7	1.75	1.5	1.30	1.20	1.44	1.43	1.9
3	1.34	1.36	1.5	1.95	1.65	1.85	1.48	1.28	1.18	1.38	1.42	1.65
4	1.65	1.5	1.46	1.9	1.6	2.0	1.8	1.25	1.7	1.36	1.41	1.5
5	1.41	1.43	1.42	1.8	1.6	1.8	1.6	1.20	2.6	1.33	1.39	1.46
6	1.42	1.37	1.38	1.8	1.6	1.75	1.48	1.95	1.9	1.30	1.38	1.43
7	1.40	1.32	1.32	1.75	1.6	1.7	1.36	1.34	1.5	1.30	1.38	1.48
8	1.41	1.25	1.32	1.75	1.8	1.8	1.30	1.48	1.40	1.30	1.40	1.55
9	1.34	1.34	1.34	1.8	1.8	2.0	1.30	1.46	1.37	1.33	1.85	1.55
10	1.30	1.40	1.44	1.7	1.6	1.75	1.28	1.42	1.36	1.38	1.7	1.5
11	1.29	1.35	1.55	2.35	1.6	1.65	1.29	1.38	1.32	1.36	1.6	1.55
12	1.30	1.34	1.48	3.1	1.55	1.75	1.38	1.30	1.28	1.35	1.46	1.5
13	1.40	1.38	1.44	3.6	1.55	1.75	1.36	1.48	1.26	1.30	1.40	1.55
14	1.31	1.26	3.6	2.6	1.5	1.6	1.32	1.5	1.25	1.28	1.42	1.48
15	1.28	1.26	3.9	2.45	1.55	1.6	1.30	1.42	1.24	1.24	1.42	1.34
16	1.21	1.26	3.2	2.45	1.7	1.55	1.28	1.36	1.41	1.24	1.44	1.32
17	1.25	1.29	2.4	2.25	1.9	1.49	1.26	1.28	1.65	1.24	1.47	1.29
18	1.26	1.26	2.05	2.1	1.9	1.49	1.24	1.36	1.6	1.26	1.42	1.30
19	1.30	1.20	1.95	2.05	1.7	1.55	1.22	1.40	1.6	1.32	1.41	1.29
20	1.28	1.34	1.8	1.95	1.7	1.65	1.22	1.71	2.05	1.75	1.38	1.28

Daily gage height, in feet, of South Fork of New River near Crumpler, N. C., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
21	1.24	1.55	1.95	1.9	1.75	1.65	1.20	1.68	3.4	1.75	1.36	1.27
22	1.23	1.6	2.1	1.85	2.0	1.5	1.18	1.56	2.5	1.5	1.34	1.27
23	1.22	1.48	1.85	1.8	2.4	1.48	1.22	1.52	1.9	1.44	1.34	1.29
24	1.24	1.40	1.8	1.8	4.0	1.8	1.26	1.45	1.6	2.0	1.34	1.34
25	1.33	1.32	1.75	1.8	2.8	1.48	1.28	1.40	1.55	2.8	1.31	1.42
26	1.37	1.30	2.2	1.75	2.1	1.55	1.32	1.34	1.5	2.15	1.29	1.75
27	1.75	1.6	6.1	1.85	2.4	1.46	1.34	1.26	1.47	1.75	1.28	1.65
28	2.0	2.0	3.9	1.8	2.6	1.44	1.38	1.21	1.44	1.65	1.28	1.45
29	1.75	....	2.8	1.75	2.15	1.41	1.40	1.19	1.44	1.6	1.28	1.44
30	1.55	....	2.4	1.7	1.95	1.38	1.39	1.47	1.6	1.55	1.30	1.47
31	1.48	....	2.3	....	1.9	....	1.34	1.20	....	1.48	....	1.48
1914												
1	1.5	2.6	1.65	1.95	1.7	1.33	1.05	1.04	1.07	0.98	1.22	4.0
2	1.44	1.95	1.65	1.85	1.6	1.30	1.35	1.02	1.04	.98	1.20	4.3
3	1.47	1.75	1.42	1.8	1.55	1.28	1.45	1.01	1.06	.98	1.20	3.4
4	1.5	1.7	1.8	1.7	1.55	1.24	1.26	1.16	1.01	1.02	1.20	3.7
5	1.55	1.65	1.8	1.65	1.8	1.30	1.29	1.06	1.02	1.38	1.20	4.9
6	1.42	1.9	1.7	1.6	1.9	1.7	1.38	1.04	.99	1.40	1.19	3.5
7	1.42	2.3	1.65	1.55	1.85	1.8	1.24	1.03	.93	1.18	1.18	2.8
8	1.44	2.05	1.65	1.8	1.7	1.6	1.22	1.00	.96	1.10	1.16	2.5
9	1.55	1.9	1.55	1.9	1.65	1.44	1.16	1.00	1.04	1.10	1.24	2.35
10	1.85	1.75	1.5	1.7	1.65	1.55	1.5	1.10	1.03	1.06	1.20	2.15
11	1.75	1.7	1.6	1.7	1.6	1.55	1.30	1.08	1.06	1.02	1.20	2.06
12	1.75	1.65	1.8	1.6	1.55	1.36	1.18	1.16	1.18	1.00	1.16	1.95
13	1.5	1.65	1.9	1.6	1.55	1.32	1.16	1.24	1.22	1.00	1.14	1.95
14	1.5	1.9	1.75	1.7	1.5	1.30	1.16	1.20	1.10	1.16	1.16	1.9
15	1.7	1.5	1.7	3.0	1.49	1.30	1.40	1.18	1.04	1.95	2.4	2.1
16	1.5	1.65	1.7	2.45	1.46	1.27	1.8	1.09	1.00	4.7	2.35	1.8
17	1.5	1.6	1.7	2.2	1.44	1.20	1.6	1.06	1.08	2.45	2.0	1.8
18	1.42	1.75	1.8	2.0	1.44	1.20	1.5	1.02	1.32	1.8	1.6	1.85
19	1.42	2.0	1.85	1.95	1.45	1.32	1.38	.99	1.40	1.65	1.48	1.8
20	1.41	2.3	1.8	2.05	1.44	1.39	1.32	.96	1.25	1.55	1.40	1.9
21	1.42	2.35	1.7	1.95	1.40	1.30	1.21	1.00	1.14	1.46	1.30	2.0
22	1.40	2.05	1.65	1.9	1.40	1.20	1.11	1.08	1.08	1.40	1.47	1.95
23	1.45	1.8	1.6	1.8	1.40	1.19	1.07	.98	1.07	1.36	1.55	1.85
24	1.42	1.9	1.6	1.75	1.38	1.16	1.06	.90	1.04	1.55	1.49	1.7
25	1.48	1.8	1.55	1.7	1.35	1.15	1.02	.92	1.07	1.5	1.36	2.3
26	1.6	1.75	1.5	1.7	1.34	1.16	1.02	1.16	1.04	1.45	1.38	2.7
27	1.5	1.7	1.6	1.6	1.32	1.16	1.20	1.18	1.04	1.40	1.32	2.45
28	1.42	1.7	1.5	1.6	1.30	1.10	1.11	1.85	.98	1.30	1.33	2.05
29	1.41	....	1.65	1.6	1.31	1.05	1.09	1.8	.98	1.26	1.37	2.05
30	1.40	....	1.7	1.65	1.42	1.02	1.04	1.46	.98	1.24	2.6	2.2
31	3.0	....	1.85	....	1.38	....	1.06	1.22	....	1.24	....	2.0

NOTE.—Ice in stream on following dates:

1909: Dec. 10-31, ice about 0.75 foot thick Dec. 31.
1910: Jan. 1-11, and during December.
1911: Slush ice reported Feb. 23.
1912: Jan. 5-29, ice from 4 to 12 inches thick; Feb. 3-17, ice from 4 to 5 inches thick.
1913: Feb. 9-17.
1914: Jan. 13-16 and Feb. 14-17.

NEW RIVER NEAR GRAYSON, VA.

Location.—At Norfolk & Western Railway bridge at Fries Junction, immediately above mouth of Chestnut Creek, and one mile above Grayson.

Drainage area.—1,160 square miles.

Records available.—August 7, 1908, to December 31, 1912. Station discontinued January 4, 1913, because of backwater from Appalachian Power Co.'s dam No. 2.

Gage.—Chain attached to railroad bridge; read twice daily.

Discharge measurements.—Made from railroad bridge.

Channel and control.—River at measuring section is wide; irregular rocky bottom; current rough and rapid. Control practically permanent.

Extremes of discharge.—Maximum stage observed: 10.0 feet at 6 p. m., May 21, 1909. Minimum stage observed: 2.98 feet at 7 a. m., August 25, 1911.

Winter flow.—Discharge relation seldom if ever affected by ice.

Regulation.—Operation of a cotton mill about 4 miles above station affected natural flow during low water.

Accuracy.—Accurate discharge measurements difficult to obtain because of irregular channel.

Data insufficient for estimating discharge.

Discharge measurements of New River near Grayson, Va.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1908				1910			
Aug. 6...	O'Neill and Chapman	4.70	3,170	Mar. 17..	C. T. Bailey........	3.96	1,480
Aug. 19...	W. M. O'Neill......	4.11	1,920	Oct. 22...	.....do	4.00	1,470
1909				1911			
June 14 ...	H. J. Jackson......	4.74	3,110	July 21...	C. T. Bailey	3.69	[a] 872
June 21 ...	.....do	4.45	2,390	1912			
				Sept. 25..	Bailey and Carr....	4.62	3,070

[a] Measurement made at Grayson and inflow of Chestnut and Brush creeks, determined by floats, deducted, to obtain flow at gaging station at Fries Junction.

Daily gage height, in feet, of New River near Grayson, Va., for 1908–1912.

[Wm. J. Matkins and Oscar Williams, observers.]

Day	Aug.	Sept.	Oct.	Nov.	Dec.	Day	Aug.	Sept.	Oct.	Nov.	Dec.
1908						1908					
1	....	4.19	4.02	5.22	4.28	16	4.05	3.94	3.99	4.38	4.52
2	....	4.15	3.98	4.98	4.27	17	4.25	3.90	3.98	4.35	4.37
3	....	4.11	3.95	4.76	4.18	18	4.10	3.90	3.89	4.38	4.32
4	....	4.09	3.88	4.76	4.18	19	4.10	3.90	3.88	4.46	4.46
5	....	4.08	3.80	4.56	4.22	20	4.05	3.90	3.88	4.46	4.37
6	5.04	4.35	3.80	4.50	4.30	21	3.92	3.89	3.88	4.36	4.29
7	4.16	4.32	3.80	4.40	5.23	22	4.01	3.88	3.96	4.33	4.30
8	4.18	4.60	3.80	4.36	6.18	23	4.32	3.88	5.06	4.32	4.46
9	4.14	4.22	3.94	4.35	5.26	24	4.25	3.87	9.20	4.28	4.41
10	4.16	4.11	5.32	4.34	4.83	25	5.30	3.87	6.38	4.27	4.37
11	4.23	4.02	5.30	4.33	4.66	26	6.85	3.87	5.36	4.24	4.62
12	4.24	4.00	4.48	4.35	4.78	27	5.55	3.87	4.88	4.22	4.72
13	3.99	3.99	4.20	4.34	4.83	28	4.82	4.00	4.80	4.20	4.65
14	4.44	3.98	4.07	4.33	4.66	29	4.62	4.20	5.58	4.21	4.60
15	4.00	3.95	4.00	4.33	4.63	30	4.52	4.12	6.53	4.18	4.79
						31	4.35	....	5.68	....	5.24

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	5.32	4.07	4.64	4.64	5.27	4.67	4.74	4.40	3.80	3.75	3.45	3.78
2	5.47	4.35	4.54	4.58	5.25	4.55	4.62	4.66	3.76	3.74	3.80	3.79
3	4.81	4.57	4.46	4.48	4.80	4.63	4.54	4.62	3.76	3.70	3.79	3.79
4	4.65	4.51	4.52	4.46	4.65	6.55	4.40	4.46	3.78	3.74	3.79	3.74
5	5.32	4.37	4.52	4.42	4.55	6.43	4.30	4.35	3.82	3.80	3.79	3.68
6	6.15	4.47	4.54	4.34	4.49	5.47	4.30	4.28	3.88	3.76	3.79	3.67
7	5.37	4.39	4.84	4.26	4.41	5.11	4.39	5.30	3.88	3.79	3.78	3.75
8	4.99	4.32	4.88	4.26	4.84	4.85	4.98	4.10	3.85	3.78	3.79	4.12
9	4.87	4.27	4.80	4.31	4.25	4.80	4.69	4.06	3.86	3.75	3.45	4.15
10	4.69	5.29	4.76	4.28	5.00	5.00	4.52	4.00	3.85	3.72	3.85	3.88
11	4.63	5.61	4.76	4.23	5.65	4.73	4.42	3.98	3.85	4.24	3.90	3.68
12	4.55	4.92	4.72	4.20	4.93	4.60	4.30	4.01	3.80	5.55	3.91	3.79
13	4.45	4.65	4.70	4.70	4.60	4.67	4.30	4.00	3.78	4.55	3.80	4.25
14	4.42	4.54	4.66	6.47	4.47	4.85	4.30	4.05	3.78	4.09	3.79	4.91
15	4.43	4.47	4.58	5.50	4.41	4.65	4.26	4.30	3.76	4.08	3.78	4.60
16	4.55	4.82	4.50	4.95	4.36	4.56	4.17	4.68	3.75	4.26	3.79	4.18
17	5.39	5.01	4.46	4.75	4.31	4.40	4.12	4.69	4.04	4.18	3.81	3.98
18	5.15	4.78	4.43	4.60	4.25	4.38	4.10	4.36	4.04	4.06	3.73	3.91
19	4.95	4.70	4.37	4.47	4.23	4.59	4.06	4.14	4.01	3.96	3.70	3.90
20	4.75	4.98	4.34	4.45	4.30	4.51	4.02	4.05	3.85	3.92	3.74	3.93
21	4.61	4.86	4.40	4.44	9.10	4.44	3.98	3.99	3.86	3.95	3.72	3.74
22	4.55	4.91	4.51	4.40	7.68	4.35	3.96	3.94	3.91	3.92	3.73	3.68
23	4.47	5.06	4.47	4.37	5.87	4.32	4.01	3.89	4.18	3.96	3.75	3.68
24	4.45	5.11	4.42	4.31	4.40	4.42	4.08	3.88	4.28	3.98	3.78	3.75
25	4.42	5.34	4.58	4.26	5.15	4.49	4.02	3.87	4.12	3.95	3.82	3.88
26	4.42	5.16	4.91	4.25	5.15	4.48	4.10	3.85	4.01	3.89	3.79	3.94
27	4.41	4.94	4.80	4.25	5.23	4.54	4.48	3.85	3.95	3.88	3.78	3.76
28	4.37	4.74	4.98	4.25	5.05	4.48	4.30	3.82	3.84	3.83	3.76	3.84
29	4.36	....	5.58	4.23	4.83	4.52	4.22	3.80	3.80	3.83	3.71	3.89
30	4.33	....	5.08	4.30	4.78	4.62	4.18	3.78	3.80	3.89	3.72	3.84
31	4.05	....	4.84	....	4.70	....	4.16	3.81	....	3.90	....	3.92
1910												
1	3.98	3.80	4.92	3.80	3.90	3.80	4.10	3.85	5.79	3.88	3.81	3.72
2	4.08	3.82	5.06	3.79	3.86	3.77	4.00	3.80	5.16	3.81	3.80	3.70
3	4.54	3.99	4.85	3.84	3.85	3.78	4.02	3.96	4.87	3.77	3.82	3.69
4	4.46	4.16	4.60	3.88	3.84	3.73	3.62	3.92	4.63	3.75	3.80	3.72
5	4.20	4.02	4.46	3.84	3.84	3.82	4.30	4.08	4.50	3.72	3.78	3.86

Daily gage height, in feet, of New River near Grayson, Va., for 1908–1912—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
6	4.08	3.88	4.40	3.79	3.81	4.11	4.62	3.95	4.29	3.82	3.78	4.20
7	4.55	3.89	4.40	3.79	3.76	4.14	4.52	3.85	4.12	4.44	3.76	4.50
8	4.85	3.86	4.22	3.73	4.00	3.88	4.54	3.93	4.05	5.82	3.75	4.48
9	4.40	3.99	4.17	3.72	4.40	3.86	4.98	3.92	4.01	5.31	3.75	4.26
10	4.10	3.96	4.14	3.66	4.34	3.96	4.42	3.83	3.99	4.65	3.74	4.12
11	3.99	4.04	4.13	3.68	4.12	4.82	4.26	3.78	3.99	4.27	3.74	4.00
12	3.92	3.80	4.14	3.70	4.08	6.08	4.40	3.76	3.92	4.11	3.70	3.90
13	4.10	3.80	4.11	4.01	4.08	6.50	4.75	3.80	3.92	4.01	3.70	3.73
14	4.10	3.91	4.01	4.05	4.04	6.09	4.50	3.87	3.89	3.97	3.72	3.68
15	4.04	4.02	3.98	3.93	3.94	5.93	4.22	3.80	3.87	3.93	3.76	3.65
16	3.98	4.34	3.92	3.88	3.90	5.46	4.15	3.75	3.82	3.89	3.78	3.79
17	3.92	4.80	3.91	3.98	3.88	5.04	4.36	3.87	3.79	3.87	3.78	3.70
18	3.98	6.06	3.90	4.11	3.90	4.70	4.40	3.70	3.75	3.85	3.71	3.81
19	3.95	5.33	3.89	4.08	3.95	4.52	4.26	3.72	3.73	3.86	3.72	3.92
20	3.98	4.67	3.90	3.96	3.92	4.42	4.14	3.76	3.72	3.97	3.71	3.89
21	4.10	4.58	3.98	3.93	3.90	4.62	4.01	3.78	3.73	4.12	3.70	3.72
22	4.82	4.54	3.92	3.90	3.90	4.68	3.98	3.88	3.75	4.02	3.70	3.35
23	4.36	4.45	3.91	3.89	4.14	4.54	3.94	3.88	3.70	3.88	3.68	3.80
24	4.25	4.32	3.85	3.88	4.14	4.22	3.90	3.80	3.69	3.85	3.69	4.00
25	4.18	4.26	3.86	3.98	4.28	4.61	3.86	3.76	3.71	3.81	3.72	4.22
26	4.06	4.18	3.85	4.04	4.45	4.46	3.86	3.75	3.75	3.80	3.72	4.08
27	3.97	4.12	3.84	4.12	4.20	4.32	3.84	3.76	3.87	3.80	3.71	4.06
28	4.00	4.80	3.86	4.11	4.06	4.20	3.84	3.74	3.99	3.86	3.75	4.04
29	3.99	....	3.81	4.06	3.96	4.12	3.90	3.74	3.97	3.84	3.77	4.13
30	4.00	....	3.81	3.94	3.90	4.12	3.96	3.75	3.98	3.83	3.92	4.25
31	3.97	....	3.79	....	3.85	....	3.88	4.23	....	3.82	....	4.36
1911												
1	4.31	4.70	3.88	4.24	4.50	4.00	3.65	3.46	4.42	3.59	3.70	3.83
2	5.31	4.44	3.88	4.18	4.52	3.89	3.62	3.59	4.09	3.44	3.68	3.79
3	5.92	4.26	3.89	4.16	4.37	3.86	3.58	3.55	4.81	3.60	3.69	3.79
4	6.16	4.17	3.86	4.18	4.27	3.80	3.59	3.74	3.66	3.58	3.64	3.78
5	5.24	4.20	3.80	5.74	4.22	3.80	3.72	3.94	3.60	3.59	3.66	3.73
6	4.70	4.10	3.87	6.69	4.18	4.26	4.08	3.86	3.60	3.64	3.74	3.74
7	4.40	4.09	4.46	5.68	4.15	4.12	3.78	3.82	3.61	3.58	4.18	3.78
8	4.37	4.12	4.90	5.61	4.14	4.06	3.89	3.80	3.63	3.55	4.25	3.78
9	4.22	4.84	5.49	5.29	4.10	3.84	3.82	3.68	3.54	3.56	4.10	3.72
10	4.11	5.26	5.42	4.95	4.09	3.87	3.78	3.60	3.60	3.58	4.09	3.70
11	3.98	4.94	5.18	4.82	4.06	3.82	3.78	3.62	3.61	3.62	4.06	3.70
12	4.09	4.63	4.62	4.78	4.05	3.79	3.79	3.48	3.84	3.72	4.00	3.72
13	4.06	4.47	4.50	4.96	4.24	3.78	3.82	3.65	3.78	3.70	4.06	3.74
14	4.00	4.37	4.44	5.39	4.89	3.74	3.82	3.56	3.67	3.63	4.05	3.72
15	4.00	4.24	4.38	5.68	4.48	3.69	3.82	3.62	3.55	3.60	3.98	3.79
16	4.04	4.16	4.28	5.57	4.25	3.68	3.70	3.55	3.56	3.68	3.90	4.00
17	3.98	4.10	4.16	5.18	4.13	3.67	3.66	3.54	3.51	4.00	3.86	4.20
18	3.95	4.06	4.10	4.86	4.08	3.70	3.59	3.51	3.55	7.22	3.82	4.10
19	3.92	4.02	4.12	4.76	4.06	3.73	3.55	3.54	3.54	5.26	3.92	3.92
20	3.93	4.02	4.19	5.00	4.00	3.84	3.59	3.54	3.50	4.42	3.92	3.90
21	3.94	4.11	4.17	4.84	3.99	3.90	3.60	3.28	3.59	4.26	3.90	3.89
22	4.00	3.94	4.07	4.67	3.98	3.76	3.57	3.46	4.51	4.00	3.85	4.84
23	3.98	3.87	4.02	4.56	3.96	3.69	3.27	3.29	4.10	4.10	3.82	5.38
24	4.17	3.96	4.02	4.46	3.94	3.68	3.56	3.28	3.86	4.04	3.82	4.93
25	4.28	3.94	4.01	4.38	3.94	3.76	3.54	3.26	3.78	3.92	3.90	4.76
26	4.18	3.91	3.98	4.32	3.90	3.78	3.50	3.31	3.69	3.82	3.88	4.60
27	4.16	3.90	4.34	4.26	3.86	3.74	3.54	3.74	3.62	3.79	3.82	4.62
28	4.13	3.89	4.58	4.21	3.83	4.04	3.54	3.70	3.60	3.78	3.84	4.56
29	4.20	....	4.43	4.24	3.81	3.90	3.41	3.74	3.58	3.75	3.84	4.31
30	4.25	....	4.33	4.28	3.80	3.77	3.53	4.14	3.53	3.73	3.87	4.30
31	4.59	....	4.32	....	3.87	....	3.56	4.17	....	3.72	....	4.29

Daily gage height, in feet, of New River near Grayson, Va., for 1908–1912—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	4.5	4.4	4.45	4.9	4.45	4.05	4.2	4.05	3.66	3.82	3.60	3.69
2	4.35	4.25	4.35	5.1	4.4	4.0	4.0	3.96	3.66	3.80	3.67	3.82
3	4.3	4.05	4.2	5.6	4.35	4.2	4.05	3.86	3.62	3.72	3.67	3.78
4	4.15	3.78	4.25	5.3	4.2	4.2	....	3.93	3.60	3.75	3.65	3.85
5	3.89	3.81	4.3	4.8	4.2	4.1	4.4	4.0	3.63	3.71	3.61	3.92
6	3.77	3.94	4.4	4.65	4.25	4.05	4.9	3.90	3.66	3.68	3.78	3.88
7	3.68	4.1	4.35	4.6	4.25	4.15	4.6	3.83	3.62	3.67	4.0	3.90
8	4.3	4.1	4.55	4.6	4.25	4.05	4.35	3.79	3.74	3.74	4.5	3.86
9	4.4	4.05	4.75	4.45	4.15	4.0	4.1	3.82	4.0	3.65	4.8	3.81
10	4.35	4.05	4.8	4.35	4.1	3.93	4.1	3.92	3.80	3.63	3.99	3.72
11	4.35	4.05	4.65	4.3	4.1	3.89	4.15	3.98	3.67	3.62	3.86	3.70
12	4.25	3.94	4.6	4.25	5.5	3.86	4.35	3.88	3.60	3.62	3.86	3.75
13	4.35	3.79	4.85	4.25	5.1	3.82	4.4	3.8	3.98	3.65	3.85	3.60
14	4.3	3.96	4.95	4.2	4.7	3.90	4.3	3.78	3.78	3.68	3.84	3.78
15	4.65	3.9	6.0	4.2	4.5	4.1	4.2	3.77	3.72	3.79	3.88	3.66
16	4.5	3.87	7.0	4.2	4.9	4.2	4.1	3.76	3.75	3.87	3.80	3.72
17	4.25	3.98	5.8	4.25	5.4	4.05	3.99	3.78	3.68	3.76	3.71	3.83
18	4.2	3.98	5.2	4.25	4.9	3.96	4.05	3.74	3.75	3.69	3.76	3.73
19	4.25	4.1	4.85	4.2	4.6	3.92	4.2	3.74	3.98	3.72	3.68	3.71
20	4.35	4.1	4.75	4.1	4.45	3.84	4.4	3.78	3.94	3.75	3.67	3.76
21	4.55	4.4	4.6	4.1	4.35	3.81	4.35	4.55	3.74	3.76	3.56	3.65
22	4.4	5.8	4.5	4.2	4.3	3.79	4.2	4.1	3.67	3.76	3.70	3.60
23	4.2	5.0	4.4	4.5	4.2	3.86	4.1	3.94	4.15	3.79	3.68	3.68
24	4.05	4.6	4.6	4.4	4.2	3.84	4.0	3.83	5.3	3.78	3.64	3.58
25	4.1	4.65	5.2	4.2	4.1	4.5	3.98	3.78	4.7	3.75	3.56	3.65
26	4.05	4.8	4.9	4.15	4.1	4.4	4.1	3.75	4.2	3.69	3.61	3.65
27	4.05	5.4	4.65	4.2	4.05	4.3	3.98	3.84	4.1	3.67	3.77	3.84
28	4.05	5.1	4.6	4.4	4.15	4.0	3.86	3.74	4.15	3.65	3.65	3.85
29	4.1	4.7	5.1	4.4	4.25	4.1	3.83	3.68	4.1	3.65	3.59	3.75
30	4.9	....	5.9	4.5	4.3	4.4	4.25	3.68	3.96	3.64	3.61	4.0
31	4.8	....	5.2	....	4.15	....	4.2	3.69	....	3.60	....	5.9

NOTE.—Ice in stream on following dates:

1909: Dec. 9-31; Dec. 31, river frozen one-third distance across from either side.
1910: Jan. 1-4 and during December.
1911: No ice reported.
1912: No notes regarding ice. Snow and ice reported Jan. 8, and sleet and rain Jan. 29. Discharge relation probably affected by ice Jan. 6-19 and Feb. 5-17. Dec. 31 observer reported backwater from Appalachian Power Co.'s dam below station.

NEW RIVER AT RADFORD, VA.

Location.—At the toll highway bridge near Norfolk & Western Railway station at Radford, 1½ miles below Norfolk & Western Railway bridge, and 6 miles below mouth of Little River.

Drainage area.—2,720 square miles.

Records available.—August 1, 1898, to July 15, 1906; May 6, 1907, to December 31, 1914.

Gage.—Chain attached to the bridge; read twice daily. U. S. Weather Bureau gage originally used, but, owing to its inaccessibility, it was replaced by a wire gage February 23, 1900. Wire gage replaced by the chain gage December 1, 1903, and datum lowered 3.41 feet to avoid negative readings.

Discharge measurements.—Made from the bridge.

Channel and control.—Left bank does not overflow; right bank overflows only in extreme floods. The stream flows in one channel at ordinary stages. At extreme high water the channel is broken by five tubular piers and several trestle bents. Bottom, solid rock and gravel. Control section has changed at times.

Extremes of discharge.—Maximum stage observed 1898 to 1914: 30.2 feet at 2 P. M., May 22, 1901; approximate discharge, 138,000 second-feet. Flood of September 15, 1878, reached a stage of 37 feet. Minimum stage recorded: August, 1900, but stage and discharge are very doubtful because of inaccuracies in gage-height record.

Winter flow.—Discharge relation seldom affected by ice.

Regulation.—Power plants about 50 miles above may affect flow at the station to a small extent.

Accuracy.—Rating curves probably reliable except for high stages and results good except for periods when they may be affected by inaccuracies in gage-height record. Discharge estimates below about 700 second-feet for early years, therefore, may be subject to large errors.

Discharge measurements of New River at Radford, Va., in 1906–1914.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1906				1911			
June 11	R. Follansbee	3.60	1,970	July 17	Horton and Bailey	3.38	1,510
1907				1913			
June 20	R. G. Knight	4.78	5,610	Mar. 28	Jackson and Wallace	10.71	30,800
July 22	do	3.88	3,000	Mar. 28	do	10.01	27,600
1908				Mar. 29	do	7.24	15,100
July 27	O'Neill and Chapman	3.99	3,230	Mar. 29	do	6.83	13,200
Aug. 20	W. M. O'Neill	3.84	2,610	Dec. 11	Peterson and Walters	3.77	2,410
1909				1914			
June 10	H. J. Jackson	5.15	7,800	Oct. 5	Mathers and Morgan	3.21	1,040
June 22	do	4.36	4,050	Oct. 23	do	3.61	1,850
Dec. 7	A. H. Horton	3.50	1,830				
1910							
Mar. 15	C. T. Bailey	3.85	2,730				
Oct. 20	do	3.62	2,120				

Daily gage height, in feet, of New River at Radford, Va., for 1906–1914.

[C. L. Gillespie, W. T. Linkous, J. H. Lucas, and R. B. Harvey, observers.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	4.0	5.1	4.0	6.2	3.9	3.7	3.6
2	3.9	4.9	4.1	5.3	3.9	3.7	3.6
3	4.1	4.9	4.2	4.9	3.8	3.8	3.6
4	6.9	4.5	4.8	4.7	4.2	3.7	3.6
5	6.1	4.3	4.9	4.4	4.1	3.7	3.6
6	5.7	4.7	4.7	4.1	4.5	3.8	3.6
7	5.4	4.5	4.4	4.1	4.6	3.7	3.6
8	4.5	4.3	4.5	4.4	4.3	3.7	3.8
9	4.3	4.4	4.3	4.3	4.3	3.8	3.8
10	4.2	4.3	4.2	4.4	4.1	3.7	3.7
11	3.7	4.2	4.1	4.3	4.0	3.6	3.7
12	3.6	4.2	4.0	4.3	4.0	3.6	3.7
13	4.3	3.8	4.1	4.3	4.0	3.9	3.7
14	4.9	3.7	4.2	4.1	3.8	5.85	3.6
15	4.7	3.8	4.2	4.2	3.8	6.0	3.6
16	4.8	3.7	5.4	4.3	3.9	5.2	....
17	4.7	3.7	5.6	5.2	3.7	5.0	....
18	4.5	3.8	4.7	4.8	3.7	4.9	....
19	4.5	3.7	4.4	4.6	3.8	4.8	....
20	4.2	4.0	4.5	4.4	3.7	4.6	....
21	4.2	4.1	5.0	4.3	3.7	4.9	....
22	4.2	3.9	4.4	4.2	3.8	4.3	....
23	8.2	4.2	4.5	4.1	3.7	4.0	....
24	10.3	4.3	4.4	4.0	3.7	4.0	....
25	7.1	4.1	4.4	4.1	3.8	4.0	....
26	6.6	4.0	4.4	3.7	3.7	3.8	....
27	5.9	4.1	4.4	3.9	3.7	3.8	....
28	6.0	4.0	4.8	3.8	4.0	3.8	....
29	5.5	....	4.7	3.8	3.9	3.8	....
30	5.4	....	4.4	3.8	3.9	3.7	....
31	5.2	....	6.8	....	3.8	....	....

Day	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907								
1	....	3.9	4.6	3.8	3.5	4.2	3.7	3.8
2	....	5.4	4.2	3.9	3.4	4.0	3.8	3.6
3	....	5.6	4.2	3.8	3.4	3.9	3.8	3.6
4	....	5.1	4.2	3.7	3.4	3.8	4.0	3.7
5	....	4.5	4.2	3.7	5.2	3.8	4.0	3.7
6	6.7	4.0	4.1	3.6	4.8	3.7	4.0	3.7
7	6.7	3.6	4.1	3.6	4.0	3.6	3.9	3.7
8	3.8	3.4	4.1	3.6	3.8	3.6	3.8	3.8
9	3.7	4.2	3.8	3.6	3.5	3.6	3.8	3.8
10	3.7	4.0	3.8	3.6	3.4	3.6	3.8	3.9
11	4.1	5.6	3.7	3.6	3.5	3.6	3.8	4.25
12	4.0	7.2	4.0	3.7	4.1	3.6	3.8	4.3
13	3.9	14.6	4.2	3.7	3.9	3.5	4.6	4.2
14	3.9	11.8	4.7	3.6	3.7	3.5	4.0	4.2
15	3.8	6.8	4.7	3.6	3.6	3.5	4.0	4.5
16	3.8	5.5	4.5	3.6	3.5	3.5	3.9	6.7
17	3.8	4.7	4.5	3.5	3.5	3.5	3.7	6.5
18	3.8	4.1	4.6	3.5	3.5	3.5	3.7	5.4
19	3.8	3.9	4.4	4.4	3.5	3.5	3.9	4.9
20	3.9	3.7	4.3	4.0	3.5	3.5	4.0	4.3

Daily gage height, in feet, of New River at Radford, Va., for 1906–1914—Continued.

Day	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907								
21	3.8	3.7	4.1	3.9	3.5	3.5	4.0	4.2
22	3.7	3.6	4.1	3.7	3.5	3.4	4.0	4.1
23	3.8	4.4	3.8	4.1	9.5	3.4	4.9	7.4
24	3.8	5.0	3.7	3.9	11.3	3.4	5.3	7.4
25	3.8	4.8	3.7	3.9	6.4	3.6	5.4	7.0
26	3.8	5.4	3.6	3.8	5.1	3.6	5.4	5.6
27	3.8	4.8	3.6	3.8	4.5	3.6	5.4	4.8
28	3.8	4.6	3.6	3.7	4.2	3.6	5.4	4.7
29	3.8	4.6	3.6	3.5	4.2	3.6	4.6	4.5
30	3.8	4.9	3.6	3.5	4.4	3.6	4.2	4.5
31	3.8	....	3.6	3.5	....	3.7	....	4.5

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
1	5.6	4.2	4.7	4.3	4.7	4.3	4.2	4.3	4.1	3.8	5.7	4.1
2	5.0	4.2	5.6	8.1	4.7	4.15	5.2	4.1	3.9	3.8	5.5	4.5
3	4.8	3.9	5.8	7.4	4.5	4.0	4.6	3.9	3.9	3.7	5.2	4.6
4	4.6	3.8	5.2	6.4	4.5	4.1	4.5	3.8	3.8	3.7	4.9	4.3
5	5.0	3.9	5.8	5.6	4.4	8.0	5.3	3.7	3.8	3.6	4.7	4.3
6	5.0	4.85	6.8	5.0	4.3	6.1	5.2	3.7	4.2	3.5	4.5	4.2
7	5.0	5.4	6.5	5.1	4.3	5.2	5.1	4.7	4.2	3.5	4.2	4.3
8	5.0	5.0	5.9	4.8	6.05	4.9	4.9	4.0	4.9	3.5	5.0	6.8
9	5.7	4.5	5.5	4.8	5.5	4.6	5.2	4.6	4.6	3.4	4.9	5.7
10	5.6	4.4	5.2	4.6	5.0	4.4	4.8	4.2	4.2	4.1	4.3	5.0
11	5.6	4.4	5.0	4.7	4.85	4.25	4.5	4.1	4.0	6.8	4.3	4.7
12	11.8	4.9	5.0	4.5	4.6	4.3	4.3	3.9	3.8	5.0	4.5	4.5
13	9.7	8.8	5.1	4.3	4.5	4.4	4.1	3.8	3.7	4.3	4.3	5.4
14	5.9	9.0	4.9	4.4	4.4	4.25	4.1	3.7	3.4	4.0	4.2	4.9
15	5.9	9.65	4.9	4.4	4.2	5.0	4.1	3.7	3.5	3.7	4.2	4.5
16	5.6	10.7	4.8	4.5	4.2	5.1	4.0	3.6	3.5	3.6	4.5	4.5
17	5.0	9.3	4.9	4.5	4.2	5.0	3.9	3.7	3.5	3.6	4.1	4.3
18	4.9	6.7	4.9	4.5	4.3	4.5	3.9	3.7	3.5	3.6	4.1	4.3
19	4.8	5.7	4.6	4.6	4.4	4.1	3.9	3.7	3.4	3.7	4.6	4.2
20	4.6	5.3	4.7	4.5	4.7	4.2	3.9	3.7	3.4	3.7	4.7	4.3
21	4.6	5.1	4.7	4.4	5.6	4.2	3.8	3.7	3.4	3.7	4.6	4.2
22	4.4	5.0	4.8	4.2	5.3	4.2	3.8	3.7	3.4	3.6	4.4	4.2
23	4.5	4.8	4.7	4.1	5.05	4.05	3.8	5.2	3.5	3.6	4.3	4.5
24	4.5	4.9	5.3	4.2	4.8	4.4	4.5	4.2	3.5	7.7	4.2	4.9
25	4.4	4.1	5.3	4.25	4.7	4.3	4.1	4.0	3.6	8.6	4.2	4.3
26	4.2	4.1	5.1	5.4	4.5	4.2	4.1	8.0	3.6	5.8	4.1	5.2
27	4.4	5.2	4.9	5.6	4.4	4.1	3.9	6.8	3.6	5.0	4.0	5.3
28	4.8	4.9	4.7	5.1	4.2	4.1	4.1	5.2	3.6	4.8	4.0	4.9
29	4.4	4.7	4.7	4.85	4.3	4.0	4.2	4.6	4.1	5.9	4.0	4.7
30	4.3	....	4.6	4.6	4.5	4.0	4.3	4.5	3.8	8.1	4.0	5.1
31	4.2	....	4.2	....	4.5	....	4.4	4.3	....	7.7	....	6.1
1909												
1	6.0	4.5	4.8	4.9	5.9	4.7	4.7	4.1	3.4	3.4	3.4	3.3
2	5.6	3.8	4.6	4.6	5.5	4.6	4.6	5.2	3.4	3.5	3.4	3.3
3	5.1	3.9	4.6	4.4	5.4	4.5	4.5	4.9	3.3	3.5	3.4	3.3
4	4.8	3.8	4.3	4.2	4.9	4.9	4.4	4.4	3.3	3.4	3.4	3.3
5	5.0	3.6	4.3	4.2	4.5	7.9	4.1	4.0	3.3	3.3	3.4	3.3
6	7.5	3.7	4.3	4.1	4.4	6.1	4.0	4.1	3.2	3.3	3.4	3.3
7	6.2	4.0	4.2	4.1	4.4	5.6	4.3	4.1	3.2	3.3	3.4	3.5
8	5.6	3.8	5.1	4.1	4.3	5.0	4.5	4.1	3.2	3.3	3.5	3.7
9	4.9	3.8	5.2	4.0	4.2	5.7	4.9	3.9	3.5	3.3	3.4	3.8
10	4.7	5.4	5.0	4.2	4.2	5.2	4.5	3.7	4.2	3.5	3.4	3.7

Daily gage height, in feet, of New River at Radford, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
11	4.5	6.8	4.8	4.1	6.1	5.0	4.2	3.5	4.0	3.5	3.6	3.4
12	4.7	5.2	4.9	4.0	5.8	4.7	4.2	3.5	3.8	6.0	3.6	3.5
13	4.6	4.0	4.8	4.0	5.0	4.6	4.0	3.4	3.5	5.1	3.6	3.7
14	4.5	4.6	4.6	8.2	4.6	5.2	4.1	3.4	3.6	4.6	3.6	5.4
15	4.5	4.5	4.4	6.8	4.4	4.9	4.0	3.4	3.5	3.8	3.5	4.5
16	4.9	4.6	4.2	5.4	4.3	4.7	4.0	3.9	3.5	3.7	3.4	4.1
17	5.4	5.3	4.4	5.2	4.2	4.5	3.9	4.3	4.0	3.6	3.3	3.7
18	6.0	5.0	4.4	5.0	4.2	4.3	3.9	4.1	3.9	3.8	3.3	3.7
19	5.4	4.7	4.2	4.7	4.1	4.8	3.7	3.8	3.8	3.6	3.3	3.7
20	5.5	4.9	4.2	4.5	4.0	4.4	3.7	3.6	3.8	3.6	3.3	3.7
21	5.3	4.7	4.3	4.4	8.9	4.3	3.6	3.6	3.6	3.7	3.3	3.6
22	4.8	4.7	4.3	4.4	11.8	4.3	3.6	3.5	3.5	3.6	3.3	3.6
23	4.7	4.8	4.6	4.3	7.4	4.3	3.7	3.4	3.6	3.6	3.3	3.5
24	4.6	5.5	4.5	4.3	6.1	4.6	3.6	3.1	3.7	3.6	3.3	3.2
25	4.6	5.7	4.3	4.3	5.5	4.5	3.8	3.9	4.0	3.6	3.3	3.4
26	4.4	5.5	5.2	4.1	5.4	4.4	3.8	3.8	3.8	3.6	3.3	3.8
27	4.3	5.4	5.2	4.1	6.1	4.3	3.7	3.8	3.7	3.6	3.3	3.5
28	4.2	5.2	5.0	4.0	5.6	4.3	3.7	3.7	3.6	3.6	3.3	3.4
29	4.2	....	5.6	4.0	5.1	4.8	4.3	3.5	3.5	3.5	3.3	3.3
30	4.0	....	5.4	4.0	4.9	4.6	4.1	3.4	3.4	3.5	3.3	3.3
31	4.6	....	5.3	....	4.8	....	4.0	3.4	....	3.5	....	3.3
1910												
1	3.4	3.8	4.1	3.6	3.8	3.4	4.0	3.4	5.2	3.5	3.45	3.4
2	3.4	3.9	4.1	3.7	3.7	3.4	4.0	3.35	5.25	3.5	3.5	3.25
3	3.9	3.7	4.9	3.6	3.7	3.5	3.9	3.4	4.25	3.4	3.5	3.15
4	4.8	3.7	5.8	3.95	3.65	3.4	4.15	3.5	4.3	3.4	3.4	3.2
5	4.1	3.8	5.2	3.85	3.6	3.45	4.15	3.7	4.3	3.55	3.4	3.4
6	4.2	3.8	4.5	3.8	3.55	3.6	3.95	3.6	4.2	3.4	3.5	3.6
7	4.2	3.6	4.5	3.6	3.5	4.0	4.35	3.7	4.1	3.55	3.4	4.6
8	4.4	3.8	4.4	3.5	3.55	3.8	4.55	3.6	4.1	4.9	3.45	4.3
9	4.4	3.8	4.3	3.5	3.75	3.8	4.5	3.6	3.8	6.05	3.4	3.8
10	3.6	3.9	4.2	3.4	4.25	3.95	4.6	3.5	3.75	5.0	3.4	3.75
11	3.4	3.9	4.1	3.45	3.95	5.05	4.25	3.6	3.65	4.2	3.4	3.65
12	3.7	3.9	4.1	3.45	3.9	7.9	4.0	3.45	3.5	3.9	3.4	3.35
13	3.8	3.1	3.8	4.05	3.8	9.1	4.55	3.4	3.5	2.9	3.3	3.3
14	3.9	3.2	3.8	4.2	3.75	9.7	4.85	3.4	3.5	2.95	3.35	3.15
15	3.9	3.5	3.7	4.05	3.7	7.05	4.5	3.5	3.55	3.0	3.3	2.95
16	3.7	4.7	3.8	3.85	3.6	6.55	4.05	3.4	3.55	2.9	3.35	3.3
17	3.6	4.8	3.75	3.9	3.7	5.85	4.3	3.5	3.3	2.9	3.45	3.45
18	3.6	8.4	3.8	4.7	3.7	5.1	4.95	3.4	3.3	3.4	3.5	3.45
19	3.7	7.2	3.75	4.15	3.8	4.95	4.55	3.5	3.3	3.5	3.4	3.5
20	3.8	5.1	3.75	3.95	3.8	4.75	4.0	3.4	3.4	3.6	3.4	3.5
21	4.1	5.4	3.8	3.85	3.6	4.5	4.0	3.5	3.4	3.5	3.4	3.35
22	4.2	4.8	3.8	3.85	3.7	4.55	3.75	3.5	3.25	3.65	3.35	3.3
23	4.6	4.6	3.8	3.75	3.9	4.55	3.75	3.6	3.3	3.6	3.4	3.2
24	4.4	4.5	3.75	3.7	4.2	4.45	3.7	3.5	3.2	3.5	3.25	3.2
25	4.2	4.3	3.7	3.75	4.3	5.05	3.6	3.55	3.2	3.45	3.2	3.3
26	4.1	4.1	3.7	3.9	4.5	4.75	3.55	3.5	3.3	3.4	3.3	3.5
27	3.9	4.1	3.7	4.2	4.45	4.1	3.5	3.7	3.5	3.45	3.3	3.7
28	3.8	4.1	3.6	4.0	4.15	4.1	3.5	3.6	3.5	3.5	3.45	3.7
29	3.4	....	3.6	3.95	3.8	4.05	3.4	3.6	3.6	3.4	3.5	3.8
30	3.8	....	3.6	3.8	3.75	3.85	3.4	3.5	3.55	3.4	3.45	3.85
31	3.9	....	3.55	....	3.5	....	3.2	3.3	....	3.4	....	4.0
1911												
1	4.5	5.05	3.6	4.25	4.2	3.8	3.5	3.15	4.63	3.28	3.25	3.02
2	5.3	4.6	3.5	4.15	4.3	3.65	3.3	3.08	4.26	3.33	3.06	3.10
3	6.3	4.3	3.5	4.05	4.2	3.45	3.25	3.08	3.91	3.75	3.11	3.63
4	7.1	4.05	3.5	4.6	4.15	3.55	3.3	3.10	3.60	3.81	3.08	3.61
5	5.4	4.0	3.6	5.9	4.0	3.6	3.4	3.69	3.41	3.51	2.99	3.53

Daily gage height, in feet, of New River at Radford, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
6	4.7	4.0	3.7	8.1	3.95	3.65	3.6	4.24	3.26	3.43	3.30	3.52
7	4.5	3.9	4.1	6.85	4.0	4.2	3.5	3.68	3.00	3.34	3.39	3.62
8	4.4	4.0	4.7	6.45	4.0	4.15	4.55	3.50	3.10	3.28	3.75	3.63
9	3.9	4.95	5.2	6.2	4.0	3.95	3.75	3.41	3.05	3.44	3.77	3.60
10	3.95	5.95	5.95	5.55	4.0	3.7	3.6	3.30	3.15	3.53	3.50	3.56
11	3.85	5.2	5.7	5.2	3.85	3.6	3.75	3.20	3.15	3.63	3.29	3.60
12	3.65	4.75	5.0	5.0	3.8	4.05	3.55	3.08	3.21	3.64	3.65	3.59
13	3.7	4.45	4.75	5.05	3.95	3.6	3.5	3.38	3.11	3.53	3.75	3.60
14	3.65	4.35	4.5	5.35	4.6	3.6	3.55	3.49	3.27	3.48	3.57	3.62
15	3.7	3.9	4.6	5.35	4.35	3.35	3.55	3.29	3.17	3.44	3.53	4.00
16	3.65	4.15	4.35	6.3	4.3	3.35	3.5	3.22	3.00	3.55	3.74	4.55
17	3.5	3.95	4.15	5.55	4.05	3.3	3.35	3.17	2.96	3.41	3.75	4.53
18	3.6	3.9	4.05	5.1	4.05	3.3	3.4	3.15	2.96	3.11	3.57	4.17
19	3.6	4.0	4.1	4.9	4.0	3.35	3.3	3.12	3.05	6.06	3.44	3.93
20	3.65	4.0	3.9	4.95	3.8	3.45	3.25	3.09	2.87	4.51	3.30	3.85
21	3.65	3.95	4.0	5.15	3.75	3.6	3.25	3.05	2.92	3.96	3.73	3.83
22	·3.95	3.7	3.9	5.0	3.35	3.55	3.2	2.85	3.99	3.96	3.68	3.94
23	4.8	3.6	3.85	4.7	3.7	3.45	3.1	2.96	4.25	4.11	3.63	5.63
24	4.65	3.6	3.7	4.5	3.8	3.35	3.1	2.97	3.85	3.51	3.73	5.48
25	4.35	3.6	3.8	4.35	3.8	3.45	3.15	2.88	3.29	3.43	3.63	5.22
26	4.2	3.7	3.85	4.2	3.75	3.55	3.15	2.95	3.26	3.48	3.75	5.24
27	3.95	3.75	4.0	4.2	3.55	3.5	3.06	3.30	3.55	3.31	3.72	5.26
28	3.95	3.7	4.35	4.2	3.45	3.35	3.19	3.41	3.57	3.20	3.65	5.18
29	4.05	....	4.35	4.15	3.45	4.0	3.11	4.56	3.34	3.32	3.04	4.94
30	4.4	....	4.2	4.2	3.5	3.55	3.11	4.36	3.35	3.30	3.15	4.30
31	5.4	....	4.2	....	3.55	....	3.18	4.62	....	3.22	....	4.33
1912												
1	4.5	4.2	4.8	5.5	4.7	4.1	4.15	3.75	3.31	3.6	3.34	3.34
2	4.5	4.8	4.45	5.6	4.6	3.9	4.15	3.65	3.23	3.55	3.34	3.20
3	4.3	4.05	....	6.7	4.4	4.0	3.9	3.5	3.41	3.55	3.38	3.65
4	4.2	3.6	....	5.9	4.25	4.2	4.05	4.2	3.27	3.55	3.12	3.6
5	3.8	3.46	....	5.3	4.2	4.0	4.3	4.2	3.23	3.40	3.45	3.6
6	3.29	3.65	....	5.0	4.25	3.9	5.0	4.4	3.19	3.38	3.37	3.85
7	3.80	3.8	....	4.9	4.3	3.9	4.5	4.6	3.18	3.38	3.5	3.7
8	3.55	3.95	....	4.9	4.3	3.9	4.20	4.7	3.39	3.47	4.5	3.65
9	3.8	3.95	....	4.7	4.2	3.8	3.95	4.25	3.49	3.42	4.35	3.6
10	4.0	3.8	5.3	4.6	4.1	3.75	3.95	3.85	3.55	3.36	4.05	3.55
11	4.05	3.8	5.1	4.5	4.05	3.75	4.0	3.65	3.42	3.28	3.7	3.46
12	4.0	3.8	4.9	4.4	9.2	3.7	4.15	3.75	3.33	3.29	3.65	3.42
13	4.0	3.65	6.0	4.3	6.8	3.65	4.15	3.45	3.29	3.28	3.6	3.5
14	3.85	3.8	5.9	4.25	5.4	3.65	4.05	3.45	3.37	3.41	3.55	3.55
15	3.85	3.75	7.6	4.25	5.0	3.85	3.95	3.5	3.39	3.6	3.65	3.55
16	4.0	3.65	9.6	4.25	6.3	3.95	3.85	3.6	3.31	3.6	3.7	3.26
17	3.95	3.65	6.8	4.25	6.9	4.0	3.7	3.7	3.45	3.42	3.55	3.55
18	3.65	3.85	5.9	4.35	5.6	3.8	3.7	3.55	3.65	3.42	3.28	3.55
19	3.95	3.9	5.3	4.25	5.2	3.85	3.95	3.48	3.75	3.5	3.6	3.49
20	4.35	4.05	5.0	4.15	4.8	3.7	3.9	3.42	3.85	3.42	3.6	3.36
21	4.35	4.2	4.9	4.1	4.6	3.6	3.95	3.43	3.6	3.18	3.48	3.42
22	4.35	7.3	4.7	4.45	4.45	3.55	3.95	3.7	3.39	3.5	3.30	3.47
23	4.05	5.7	4.6	4.45	4.35	3.65	3.75	3.65	4.15	3.49	3.32	3.28
24	4.0	4.9	4.8	4.4	4.25	3.9	3.65	3.5	6.1	3.38	3.38	3.55
25	3.95	5.1	5.7	4.3	4.15	4.1	3.65	3.39	5.3	3.49	3.38	3.28
26	3.95	5.2	5.5	4.1	4.1	4.5	3.6	3.37	4.8	3.45	3.38	3.20
27	3.95	6.5	5.1	4.1	4.05	4.25	3.7	3.37	4.05	3.45	3.55	3.20
28	3.9	5.7	4.8	4.15	4.05	4.5	3.6	3.44	3.95	3.36	3.40	3.31
29	3.95	5.1	8.5	4.35	4.2	3.9	3.44	3.30	3.95	3.38	3.32	3.6
30	4.8	....	7.5	4.8	4.25	3.95	3.42	3.37	3.75	3.42	3.44	3.39
31	5.3	....	6.1	....	4.2	....	3.44	3.38	....	3.41	....	3.8

Daily gage height, in feet, of New River at Radford, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
1	4.2	4.15	5.4	5.1	4.0	4.8	3.75	3.46	3.65	3.55	3.55	3.55
2	3.95	4.05	5.8	4.8	3.95	4.5	3.7	3.43	3.5	3.6	3.5	4.45
3	3.9	4.0	4.3	4.6	3.9	4.3	4.6	3.43	3.55	3.55	3.48	4.35
4	3.9	4.05	4.05	4.5	3.9	5.2	4.8	3.28	3.9	3.55	3.7	4.05
5	3.95	4.15	3.95	4.4	3.9	4.5	4.9	3.24	4.1	3.49	3.65	3.85
6	3.9	4.2	3.9	4.25	3.9	4.35	4.3	3.28	4.1	3.36	3.6	3.75
7	4.0	3.9	3.7	4.2	3.9	4.2	3.95	3.27	4.0	3.45	3.55	3.85
8	3.9	3.5	3.65	4.2	3.85	4.3	3.75	3.55	3.7	3.55	3.48	3.75
9	3.8	3.5	3.7	4.15	3.9	4.4	3.7	3.46	3.7	3.6	4.35	3.75
10	3.65	3.6	3.7	4.1	3.85	4.4	3.6	3.44	3.6	3.65	4.3	3.8
11	3.7	3.85	4.0	4.2	3.8	4.2	3.65	3.65	3.55	3.6	4.0	3.75
12	3.75	3.75	4.0	5.8	3.8	4.3	4.0	3.7	3.5	3.5	3.85	3.6
13	3.8	3.75	4.0	8.6	3.75	4.15	3.7	4.0	3.45	3.35	3.75	3.65
14	3.8	3.5	7.9	7.2	3.75	4.1	3.6	3.7	3.42	3.55	3.75	3.65
15	3.7	3.55	9.8	5.9	3.7	3.95	3.7	3.7	3.27	3.55	3.75	3.7
16	3.7	3.5	9.0	5.5	3.85	3.9	3.65	3.6	3.55	3.6	3.6	3.7
17	3.6	3.6	6.6	5.4	4.15	3.85	3.6	3.55	3.55	3.55	3.65	3.65
18	3.6	3.49	5.2	5.1	4.4	3.8	3.6	3.32	3.55	3.48	3.9	3.55
19	3.55	3.65	5.0	4.8	4.2	3.75	3.55	3.8	3.49	3.5	3.8	3.6
20	3.5	3.9	4.8	4.6	4.0	3.8	3.42	3.8	3.6	3.95	3.75	3.65
21	3.55	3.75	4.5	4.3	4.0	3.75	3.49	4.0	5.9	4.0	3.6	3.55
22	3.55	3.9	4.7	4.4	4.3	3.75	3.55	3.85	6.0	3.95	3.6	3.42
23	3.65	3.9	4.6	4.3	7.1	4.05	3.5	3.7	4.8	3.75	3.65	3.7
24	3.49	3.85	4.4	4.25	10.0	4.1	3.43	3.65	4.2	3.75	3.49	3.65
25	3.5	3.8	4.3	4.15	7.3	4.15	3.55	3.75	4.15	4.4	3.7	3.6
26	3.6	3.65	4.45	4.1	5.6	4.45	3.34	3.6	3.8	4.7	3.65	3.7
27	3.95	3.95	12.3	4.15	5.6	4.1	3.20	3.55	3.5	4.2	3.65	4.1
28	5.1	5.1	11.3	4.25	6.8	4.0	3.24	3.5	3.5	3.95	3.49	3.95
29	5.5	....	7.2	4.15	6.0	3.8	3.34	3.46	3.29	3.7	3.55	3.9
30	5.1	....	6.0	4.0	5.3	3.8	3.35	3.65	3.5	3.75	3.65	3.8
31	4.6	....	5.6	....	5.2	....	3.45	3.7	....	3.65	....	3.9
1914												
1	3.75	5.8	4.5	5.6	4.0	3.6	3.40	3.30	3.75	3.12	3.55	6.1
2	3.75	5.6	4.4	5.6	4.0	3.6	3.28	3.20	3.6	3.15	3.24	7.0
3	3.7	4.8	4.1	5.2	3.95	3.6	3.22	3.16	3.6	3.12	3.42	6.9
4	3.6	4.35	4.2	4.9	3.9	3.6	3.28	3.25	3.6	3.18	3.55	6.4
5	3.9	4.3	4.3	4.8	4.0	3.55	3.20	3.22	3.45	3.34	3.46	12.3
6	3.9	4.45	4.5	4.45	4.2	3.5	3.18	3.20	3.42	3.75	3.49	8.4
7	3.95	5.9	4.35	4.5	4.3	3.55	3.22	3.28	3.02	3.6	3.41	6.5
8	3.85	5.9	4.3	4.3	4.3	3.7	3.65	3.12	3.10	3.65	3.26	5.7
9	4.05	5.3	4.25	4.7	4.1	3.75	3.5	3.12	3.20	3.7	3.22	5.2
10	4.7	4.8	4.1	4.5	4.0	3.6	3.55	3.12	3.18	3.43	3.55	5.0
11	5.0	4.5	4.3	4.3	4.0	3.55	3.41	3.38	3.30	3.12	3.45	4.7
12	4.6	4.5	5.3	4.2	4.0	3.55	3.5	3.29	3.38	3.18	3.55	4.6
13	4.15	4.4	5.4	4.15	3.9	3.55	3.38	3.22	3.5	3.32	3.5	4.4
14	3.85	4.25	5.2	4.15	3.85	3.5	3.9	3.18	3.22	3.20	3.5	4.45
15	3.85	4.1	4.9	4.6	3.65	3.38	4.1	3.21	3.18	3.26	3.55	4.2
16	4.0	4.0	4.8	5.8	3.7	3.45	3.95	3.28	3.10	5.3	5.1	3.85
17	4.0	4.0	4.8	5.4	3.75	3.48	4.2	3.18	3.08	6.3	4.5	3.95
18	4.0	4.2	5.0	5.1	3.75	3.45	3.9	3.22	3.18	4.6	4.15	4.0
19	4.0	5.0	5.0	4.8	3.8	3.55	3.7	3.30	3.40	4.05	3.9	4.1
20	4.0	6.5	4.9	4.8	3.75	3.5	3.6	3.16	3.30	3.9	3.75	4.5
21	4.8	6.9	4.7	5.0	3.7	3.5	3.55	3.20	3.45	3.7	3.6	5.0
22	4.35	6.0	4.6	4.8	3.7	3.18	3.42	3.32	3.5	3.65	3.6	5.6
23	4.1	5.5	4.6	4.6	3.75	3.46	3.32	3.15	3.5	3.6	3.6	5.2
24	4.1	5.1	4.5	4.45	3.6	3.30	3.38	3.15	3.5	3.65	3.65	4.8
25	4.4	4.9	4.5	4.35	3.6	3.20	3.38	3.15	3.5	3.7	3.7	4.8

Daily gage height, in feet, of New River at Radford, Va., for 1906–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1914												
26	4.6	4.8	4.45	4.25	3.55	3.12	3.35	3.55	3.28	3.7	3.7	6.0
27	4.3	4.8	4.4	4.25	3.6	3.05	3.14	4.0	3.28	3.65	3.7	5.7
28	4.0	4.6	4.35	4.2	3.6	3.05	3.30	4.1	3.18	3.55	3.7	5.0
29	4.0	....	4.4	4.1	3.6	3.18	3.20	4.8	3.20	3.55	3.55	5.0
30	3.9	....	4.6	4.05	3.65	3.32	3.22	4.15	3.28	3.5	3.65	5.6
31	4.6	....	5.3	....	3.6	....	3.22	3.8	....	3.55	....	5.9

NOTE.—Very few notes on ice in the stream have been reported by the observers. It is probable that discharge relation was affected by ice about Jan. 7-20 and Feb. 6-13, 1912. Gage heights during May and June, 1907, and September to November, 1911, are of doubtful accuracy, as it is apparent that observers made errors of a foot or one-half foot in recording heights. These heights as far as possible have been corrected by comparison with records at other stations.

Daily discharge, in second-feet, of New River at Radford, Va., for 1906–1914.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July
1906							
1	3,290	7,160	3,290	11,600	3,000	2,430	2,160
2	3,000	6,880	3,590	7,940	3,000	2,430	2,160
3	3,590	6,380	3,900	6,380	2,710	2,710	2,160
4	14,700	4,900	6,000	5,630	3,900	2,430	2,160
5	11,200	4,220	6,380	4,550	3,590	2,430	2,160
6	9,540	5,630	5,630	3,590	4,900	2,710	2,160
7	8,340	4,900	4,550	3,590	5,260	2,430	2,160
8	4,900	4,220	4,900	4,550	4,220	2,430	2,710
9	4,220	4,550	4,220	4,220	4,220	2,710	2,710
10	3,900	4,220	3,900	4,550	3,590	2,430	2,430
11	2,430	3,900	3,590	4,220	3,290	2,160	2,430
12	2,160	3,900	3,290	4,220	3,290	2,160	2,430
13	4,220	2,710	3,590	4,220	3,290	3,000	2,430
14	6,380	2,430	3,900	3,590	2,710	10,200	2,160
15	5,630	2,710	3,900	3,900	2,710	10,800	2,160
16	6,000	2,430	8,340	4,220	3,000	7,550	....
17	5,630	2,430	9,140	7,550	2,430	6,770	....
18	4,900	2,710	5,630	6,000	2,430	6,380	....
19	4,900	2,430	4,550	5,260	2,710	6,000	....
20	3,900	3,290	4,900	4,550	2,430	5,260	....
21	3,900	3,590	6,770	4,220	2,430	6,380	....
22	3,900	3,000	4,550	3,900	2,710	4,220	....
23	20,600	3,900	4,900	3,590	2,430	3,290	....
24	30,800	4,220	4,550	3,290	2,430	3,290	....
25	15,600	3,590	4,550	3,590	2,710	3,290	....
26	13,300	3,290	4,550	2,430	2,430	2,710	....
27	10,400	3,590	4,550	3,000	2,430	2,710	....
28	10,800	3,290	6,000	2,710	3,290	2,710	....
29	8,740	....	5,630	2,710	3,000	2,710	....
30	8,340	....	4,550	2,710	3,000	2,430	....
31	7,550	....	14,200	....	2,710	....	....

Daily discharge, in second-feet, of New River at Radford, Va., for 1906–1914—Contd.

Day	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907								
1	....	3,000	5,260	2,710	1,900	3,900	2,430	2,710
2	....	8,340	3,900	3,000	1,640	3,290	2,710	2,160
3	....	9,140	3,900	2,710	1,640	3,000	2,710	2,160
4	....	7,160	3,900	2,430	1,640	2,710	3,290	2,430
5	....	4,900	3,900	2,430	7,550	2,710	3,290	2,430
6	13,800	3,290	3,590	2,160	6,000	2,430	3,290	2,430
7	13,800	2,160	3,590	2,160	3,290	2,160	3,000	2,430
8	2,710	1,640	3,590	2,160	2,710	2,160	2,710	2,710
9	2,430	3,900	2,710	2,160	1,900	2,160	2,710	2,710
10	2,430	3,290	2,710	2,160	1,640	2,160	2,710	3,000
11	3,590	9,140	2,430	2,160	1,900	2,160	2,710	4,060
12	3,290	16,000	3,290	2,430	3,590	2,160	2,710	4,220
13	3,000	52,900	3,900	2,430	3,000	1,900	5,260	3,900
14	3,000	38,400	5,630	2,160	2,430	1,900	3,290	3,900
15	2,710	14,200	5,630	2,160	2,160	1,900	3,290	4,900
16	2,710	8,740	4,900	2,160	1,900	1,900	3,000	18,800
17	2,710	5,630	4,900	1,900	1,900	1,900	2,430	12,900
18	2,710	3,590	5,260	1,900	1,900	1,900	2,430	8,340
19	2,710	3,000	4,550	4,550	1,900	1,900	3,000	6,380
20	3,000	2,430	4,220	3,290	1,900	1,900	3,290	4,220
21	2,710	2,430	3,590	3,000	1,900	1,900	3,290	3,900
22	2,430	2,160	3,590	2,430	1,900	1,640	3,290	3,590
23	2,710	4,550	2,710	3,590	26,800	1,640	6,380	16,900
24	2,710	6,770	2,430	3,000	35,800	1,640	7,940	16,900
25	2,710	6,000	2,430	3,000	12,500	2,160	8,340	15,100
26	2,710	8,340	2,160	2,710	7,160	2,160	8,840	9,140
27	2,710	6,000	2,160	2,710	4,900	2,160	8,340	6,000
28	2,710	5,260	2,160	2,430	3,900	2,160	8,340	5,630
29	2,710	5,260	2,160	1,900	3,900	2,160	5,260	4,900
30	2,710	6,380	2,160	1,900	4,550	2,160	3,900	4,900
31	2,710	....	2,160	1,900	....	2,430	....	4,900

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
1	9,140	3,900	5,630	4,220	5,630	4,220	3,900	4,220	3,590	2,710	9,540	3,590
2	6,770	3,900	9,140	20,100	5,630	3,740	7,550	3,590	3,000	2,710	8,740	4,900
3	6,000	3,000	9,950	16,900	4,900	3,290	5,260	3,000	3,000	2,430	7,550	5,260
4	5,260	2,710	7,550	12,470	4,900	3,590	4,900	2,710	2,710	2,430	6,380	4,220
5	6,770	3,000	9,950	9,140	4,550	19,600	7,940	2,430	2,710	2,160	5,630	4,220
6	6,770	6,190	14,230	6,770	4,220	11,190	7,550	2,430	3,900	1,900	4,500	3,900
7	6,770	8,340	12,900	7,160	4,220	7,550	7,160	5,630	3,900	1,900	3,900	4,220
8	6,770	6,770	10,360	6,000	10,980	6,380	6,380	3,290	6,380	1,900	6,770	14,230
9	9,540	4,900	8,740	6,000	8,740	5,260	7,550	5,260	5,260	1,640	6,380	9,540
10	9,140	4,550	7,550	5,260	6,770	4,550	6,000	3,900	3,900	3,590	4,220	6,770
11	9,140	4,550	6,770	5,630	6,190	4,060	4,900	3,590	3,290	14,230	4,220	5,630
12	38,400	6,380	6,770	4,900	5,260	4,900	4,220	3,000	2,710	6,770	4,900	4,900
13	27,800	23,400	7,160	4,220	4,900	4,550	3,590	2,710	2,430	4,220	4,220	8,340
14	10,360	24,400	6,380	4,550	4,550	4,060	3,590	2,430	1,640	3,290	3,900	6,380
15	10,360	27,600	6,380	4,550	3,900	6,770	3,590	2,430	1,900	2,430	3,900	4,900
16	9,140	32,800	6,000	4,900	3,900	7,160	3,290	2,160	1,900	2,160	4,900	4,900
17	6,770	25,900	6,380	4,900	3,900	6,770	3,000	2,430	1,900	2,160	3,590	4,220
18	6,380	13,780	6,380	4,900	4,220	4,900	3,000	2,430	1,900	2,160	3,590	4,220
19	6,000	9,540	5,260	5,260	4,550	3,590	3,000	2,430	1,640	2,430	5,260	3,900
20	5,260	7,940	5,630	4,900	5,630	3,900	3,000	2,430	1,640	2,430	5,630	4,220

Daily discharge, in second-feet, of New River at Radford, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
21	5,260	7,160	5,630	4,550	9,140	3,900	2,770	2,430	1,640	2,430	5,260	3,900
22	4,550	6,770	6,000	3,900	7,940	3,900	2,710	2,430	1,640	2,160	4,550	3,900
23	4,900	6,000	5,630	3,590	6,960	3,440	2,710	7,550	1,900	2,160	4,220	4,900
24	4,900	6,380	7,940	3,900	6,000	4,550	4,900	3,900	1,900	18,300	3,900	6,380
25	4,550	3,590	7,940	4,060	5,630	4,220	3,590	3,290	2,160	22,500	3,900	4,220
26	3,900	3,590	7,160	8,340	4,900	3,900	3,590	19,600	2,160	9,950	3,590	7,550
27	4,550	7,550	6,380	9,140	4,550	3,590	3,000	14,230	2,160	6,770	3,290	7,940
28	6,000	6,380	5,630	7,160	3,900	3,590	3,590	7,550	2,160	6,000	3,290	6,380
29	4,550	5,630	5,630	6,190	4,220	3,290	3,900	5,260	3,590	10,360	3,290	5,680
30	4,220	....	5,260	5,260	4,900	3,290	4,220	4,900	2,710	20,100	3,290	7,160
31	3,900	....	3,900	....	4,900	....	4,550	4,220	....	18,300	....	11,190
1909												
1	10,800	4,900	6,000	6,380	10,400	5,630	5,680	3,590	1,640	1,640	1,640	1,390
2	9,140	2,710	5,260	5,260	8,740	5,260	5,260	7,550	1,640	1,900	1,640	1,390
3	7,160	3,000	5,260	4,550	8,340	4,900	4,900	6,380	1,390	1,900	1,640	1,390
4	6,000	2,710	4,220	3,900	6,380	6,380	4,550	4,550	1,390	1,640	1,640	1,390
5	6,770	2,160	4,220	3,900	4,900	19,200	3,590	3,290	1,390	1,390	1,640	1,390
6	17,400	2,430	4,220	3,590	4,550	11,200	3,290	3,590	1,150	1,390	1,640	1,390
7	11,600	3,290	8,900	3,590	4,550	9,140	4,220	3,590	1,150	1,390	1,640	1,900
8	9,140	2,710	7,160	3,590	4,220	6,770	4,900	3,590	1,150	1,390	1,900	2,430
9	6,380	2,710	7,550	3,290	3,900	9,540	6,380	3,000	1,900	1,390	1,640	2,710
10	5,630	8,340	6,770	3,900	3,900	7,550	4,900	2,430	3,900	1,900	1,640	2,430
11	4,900	12,000	6,000	3,590	11,200	6,770	3,900	1,900	3,290	1,900	2,160	1,640
12	5,630	7,550	6,380	3,290	9,950	5,630	3,900	1,900	2,710	10,800	2,160	1,900
13	5,260	3,290	6,000	3,290	6,770	5,260	3,290	1,640	1,900	7,160	2,160	2,430
14	4,900	5,260	5,260	20,600	5,260	7,550	3,590	1,640	2,160	5,260	2,160	8,340
15	4,900	4,900	4,550	14,200	4,550	6,380	3,290	1,640	1,900	2,710	1,900	4,900
16	6,380	5,260	3,900	8,340	4,220	5,630	3,290	3,000	1,900	2,430	1,640	3,590
17	8,340	7,940	4,550	7,550	3,900	4,900	3,000	4,220	3,290	2,160	1,390	2,430
18	10,800	6,770	4,550	6,770	3,900	4,220	3,000	3,590	3,000	2,710	1,390	2,430
19	8,340	5,630	3,900	5,630	3,590	6,000	2,430	2,710	2,710	2,160	1,390	2,430
20	8,740	6,380	3,900	4,900	3,290	4,550	2,430	2,160	2,710	2,160	1,390	2,430
21	7,940	5,630	4,220	4,550	23,900	4,220	2,160	2,160	2,160	2,430	1,390	2,160
22	6,000	5,630	4,220	4,550	38,400	4,220	2,160	1,900	1,900	2,160	1,390	2,160
23	5,630	6,000	5,260	4,220	16,900	4,220	2,430	1,640	2,160	2,160	1,390	1,900
24	5,260	8,740	4,900	4,220	11,200	5,260	2,160	920	2,430	2,160	1,390	1,150
25	5,260	9,540	4,220	4,220	8,740	4,900	2,710	3,000	3,290	2,160	1,390	1,640
26	4,550	8,740	7,550	3,590	8,340	4,550	2,710	2,710	2,710	2,160	1,390	2,710
27	4,220	8,340	7,550	3,590	11,200	4,220	2,430	2,710	2,430	2,160	1,390	1,900
28	3,900	7,550	6,770	3,290	9,140	4,220	2,430	2,430	2,160	2,160	1,390	1,640
29	3,900	....	9,140	3,290	7,160	6,000	4,220	1,900	1,900	1,900	1,390	1,390
30	3,290	....	8,340	3,290	6,380	5,260	3,590	1,640	1,640	1,900	1,390	1,390
31	5,260	....	7,940	....	6,000	....	3,290	1,640	....	1,900	....	1,390
1910												
1	1,580	2,630	3,560	2,080	2,630	1,580	3,240	1,580	7,560	1,820	1,700	1,580
2	1,580	2,930	3,560	2,350	2,350	1,580	3,240	1,470	7,760	1,820	1,820	1,260
3	2,930	2,350	6,400	2,080	2,350	1,820	2,930	1,580	4,060	1,580	1,820	1,060
4	6,020	2,350	9,970	3,080	2,220	1,580	3,720	1,820	4,230	1,580	1,580	1,150
5	3,560	2,630	7,560	2,780	2,080	1,700	3,720	2,350	4,230	1,950	1,580	1,580
6	3,890	2,630	4,930	2,630	1,950	2,080	3,080	2,080	3,890	1,580	1,820	2,080
7	3,890	2,080	4,930	2,080	1,820	3,240	4,400	2,350	3,560	1,950	1,580	5,290
8	4,580	2,630	4,580	1,820	1,950	2,630	5,110	2,080	3,560	6,400	1,700	4,230
9	4,580	2,630	4,230	1,820	2,490	2,630	4,930	2,080	2,630	11,000	1,580	2,780
10	2,080	2,930	3,890	1,580	4,060	3,080	5,290	1,820	2,490	6,780	1,580	2,350
11	1,580	2,930	3,560	1,700	3,080	6,980	4,060	2,080	2,220	3,890	1,580	2,220
12	2,350	2,930	3,560	1,700	2,930	19,200	3,240	1,700	1,820	2,930	1,580	1,470
13	2,630	960	2,630	3,400	2,630	24,900	5,110	1,580	1,820	620	1,360	1,360
14	2,930	1,150	2,630	3,890	2,490	27,800	6,210	1,580	1,820	700	1,470	1,060
15	2,930	1,820	2,350	3,400	2,350	15,300	4,930	1,820	1,950	780	1,360	700

Daily discharge, in second-feet, of New River at Radford, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
16	2,350	5,650	2,630	2,780	2,080	13,100	3,400	1,580	1,950	620	1,470	1,360
17	2,080	6,020	2,490	2,930	2,350	10,200	4,230	1,820	1,360	620	1,700	1,700
18	2,080	21,500	2,630	5,650	2,350	7,170	6,590	1,580	1,360	1,580	1,820	1,700
19	2,350	16,000	2,490	3,720	2,630	6,790	5,110	1,820	1,360	1,820	1,580	1,820
20	2,630	7,170	2,490	3,080	2,630	5,840	3,240	1,580	1,580	2,080	1,580	1,820
21	3,560	8,350	2,630	2,780	2,080	4,930	3,240	1,820	1,580	1,820	1,580	1,470
22	3,890	6,020	2,630	2,780	2,350	5,110	2,490	1,820	1,260	2,220	1,470	1,360
23	5,290	5,290	2,630	2,490	2,930	5,110	2,490	2,080	1,360	2,080	1,580	1,150
24	4,580	4,930	2,490	2,350	3,890	4,700	2,350	1,820	1,150	1,820	1,260	1,150
25	3,890	4,230	2,350	2,490	4,230	6,980	2,080	1,950	1,150	1,700	1,150	1,360
26	3,560	3,560	2,350	2,930	4,930	5,840	1,950	1,820	1,360	1,580	1,360	1,820
27	2,930	3,560	2,350	3,890	4,760	3,560	1,820	2,350	1,820	1,700	1,360	2,350
28	2,630	3,560	2,080	3,240	3,720	3,560	1,820	2,080	1,820	1,820	1,700	2,350
29	1,580	....	2,080	3,080	2,630	3,400	1,580	2,080	2,080	1,580	1,820	2,630
30	2,630	....	2,080	2,630	2,490	2,780	1,580	1,820	1,950	1,580	1,700	2,780
31	2,930	....	1,950	....	1,820	....	1,150	1,360	....	1,580	....	3,240
1911												
1	4,930	6,980	2,080	4,060	3,890	2,630	1,820	1,060	5,400	1,320	1,260	816
2	7,950	5,290	1,820	3,720	4,230	2,220	1,360	924	4,090	1,430	888	960
3	12,100	4,230	1,820	3,400	3,890	1,700	1,260	924	2,960	2,490	979	2,160
4	15,600	3,400	1,820	5,290	3,720	1,950	1,360	960	2,080	2,660	924	2,110
5	8,350	3,240	2,080	10,400	3,240	2,080	1,580	2,320	1,600	1,850	764	1,900
6	5,650	3,240	2,350	20,100	3,080	2,220	2,080	4,030	1,280	1,650	1,360	1,870
7	4,930	2,930	3,560	14,400	3,240	3,890	1,820	2,300	780	1,450	1,560	2,130
8	4,580	3,240	5,650	12,700	3,240	3,720	5,110	1,820	960	1,320	2,490	2,160
9	2,930	6,590	7,560	11,600	3,240	3,080	2,490	1,600	870	1,680	2,550	2,080
10	3,080	10,600	10,600	8,950	3,240	2,350	2,080	1,360	1,060	1,900	1,820	1,980
11	2,780	7,560	9,560	7,560	2,780	2,080	2,490	1,150	1,060	2,160	1,340	2,080
12	2,220	5,840	6,780	6,780	2,630	3,400	1,950	924	1,170	2,190	2,220	2,050
13	2,350	4,760	5,840	6,980	3,080	2,080	1,820	1,540	979	1,900	2,490	2,080
14	2,220	4,400	4,930	8,150	5,290	2,080	1,950	1,800	1,300	1,650	2,000	2,130
15	2,350	2,930	5,290	10,200	6,210	1,470	1,950	1,340	1,090	1,680	1,900	3,240
16	2,220	3,720	4,400	12,100	4,230	1,470	1,820	1,190	780	1,950	2,460	5,110
17	1,820	3,080	3,720	8,950	3,400	1,360	1,470	1,090	716	1,600	2,490	5,040
18	2,080	2,930	3,400	7,170	3,400	1,360	1,580	1,060	716	20,200	2,000	3,790
19	2,080	3,240	3,560	6,400	3,240	1,470	1,360	998	870	11,100	1,680	3,020
20	2,220	3,240	2,930	6,590	2,630	1,700	1,260	942	578	4,970	2,630	2,780
21	2,220	3,080	3,240	7,360	2,490	2,080	1,260	870	652	3,120	2,430	2,720
22	3,080	2,350	2,930	6,780	1,470	1,950	1,150	550	3,210	3,120	2,160	3,050
23	6,020	2,080	2,780	5,650	2,350	1,700	960	716	4,060	3,590	2,160	9,270
24	5,470	2,080	2,350	4,930	2,630	1,470	960	732	2,780	1,850	2,430	8,670
25	4,400	2,080	2,630	4,400	2,630	1,700	1,060	592	1,340	1,650	2,160	7,640
26	3,890	2,350	2,780	3,890	2,490	1,950	1,060	700	1,280	1,770	2,490	7,720
27	3,080	2,490	3,240	3,890	1,950	1,820	888	1,360	1,950	1,380	2,410	7,790
28	3,080	2,350	4,400	3,890	1,700	2,780	1,130	1,600	2,000	1,150	2,220	7,480
29	3,400	....	4,400	3,720	1,700	3,240	979	5,150	1,450	1,400	852	6,550
30	4,580	....	3,890	3,890	1,820	1,950	979	4,440	1,470	1,360	1,060	4,230
31	8,350	....	3,890	....	1,950	....	1,110	5,360	....	1,190	....	4,340
1912												
1	4,930	3,890	6,020	8,750	5,650	3,560	3,720	2,490	1,380	2,080	1,450	1,450
2	4,930	4,230	4,760	9,150	5,290	2,930	3,720	2,220	1,210	1,950	1,450	1,150
3	4,230	3,400	4,600	13,800	4,580	3,240	2,930	1,820	1,600	1,950	1,540	2,220
4	3,890	2,080	4,200	10,400	4,060	3,890	3,400	3,890	1,300	1,950	998	2,080
5	2,630	1,720	4,200	7,950	3,890	3,240	4,230	3,890	1,210	1,580	1,700	2,080
6	1,340	....	6,000	6,780	4,060	2,930	6,780	4,580	1,130	1,540	1,510	2,780
7	....	....	5,300	6,400	4,230	2,930	4,930	5,290	1,110	1,540	1,820	2,350
8	....	....	4,900	6,400	4,230	2,930	3,890	5,650	1,560	1,750	4,930	2,220
9	....	....	7,200	5,650	3,890	2,630	3,080	4,060	1,800	1,630	4,400	2,080
10	....	....	7,950	5,290	3,560	2,490	3,080	2,780	1,950	1,490	3,400	1,950

Daily discharge, in second-feet, of New River at Radford, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
11	....	....	7,170	4,930	3,400	2,490	3,240	2,220	1,630	1,320	2,350	1,720
12	....	....	6,400	4,580	25,400	2,350	3,720	2,490	1,430	1,340	2,220	1,630
13	....	....	10,800	4,230	14,200	2,220	3,720	1,700	1,340	1,320	2,080	1,820
14	....	2,630	10,400	4,060	8,350	2,220	3,400	1,700	1,510	1,600	1,950	1,950
15	....	2,490	17,800	4,060	6,780	2,780	3,080	1,820	1,560	2,080	2,220	1,950
16	....	2,220	27,300	4,060	12,100	3,080	2,780	2,080	1,380	2,080	2,350	1,290
17	....	2,220	14,200	4,060	14,700	3,240	2,350	2,350	1,700	1,630	1,950	1,950
18	....	2,780	10,400	4,400	9,150	2,630	2,350	1,950	2,220	1,680	1,320	1,950
19	....	2,930	7,950	4,060	7,560	2,780	3,080	1,770	2,490	1,820	2,080	1,800
20	....	3,400	6,780	3,720	6,020	2,350	2,930	1,630	2,780	1,630	2,080	1,490
21	4,400	3,890	6,400	3,560	5,290	2,080	3,080	1,650	2,080	1,110	1,770	1,630
22	4,400	16,400	5,650	4,760	4,760	1,950	3,080	2,350	1,560	1,820	1,360	1,750
23	8,400	9,560	5,290	4,760	4,400	2,220	2,490	2,220	3,720	1,800	1,400	1,320
24	3,240	6,400	6,020	4,580	4,060	2,930	2,220	1,820	11,200	1,540	1,540	1,950
25	3,080	7,170	9,560	4,230	3,720	3,560	2,220	1,560	7,950	1,800	1,540	1,320
26	3,080	7,560	8,750	3,560	3,560	4,930	2,080	1,510	6,020	1,700	1,540	1,150
27	3,080	12,900	7,170	3,560	3,400	4,060	2,350	1,510	3,400	1,700	1,950	1,150
28	2,930	9,560	6,020	3,720	3,400	4,930	2,080	1,680	3,080	1,490	1,580	1,380
29	3,080	7,170	22,000	4,400	3,890	2,930	1,680	1,360	3,080	1,540	1,400	2,080
30	6,020	....	17,400	6,020	4,060	3,080	1,630	1,510	2,490	1,630	1,680	1,560
31	7,950	....	11,200	....	3,890	....	1,680	1,540	....	1,600	....	2,630
1913												
1	3,890	3,720	8,350	6,640	3,060	5,610	2,370	1,660	2,120	1,780	1,780	1,780
2	3,080	3,400	7,950	5,610	2,920	4,610	2,240	1,590	1,750	1,900	1,660	4,440
3	2,930	3,240	4,230	4,940	2,780	3,970	4,940	1,590	1,870	1,780	1,610	4,110
4	2,930	3,400	3,400	4,610	2,780	7,000	5,610	1,160	2,780	1,780	2,150	3,160
5	3,080	3,720	3,080	4,280	2,780	4,610	5,950	1,180	3,360	1,640	2,020	2,560
6	2,930	3,890	2,930	3,820	2,780	4,180	3,970	1,260	3,360	1,350	1,900	2,280
7	3,240	2,930	2,350	3,660	2,780	3,660	2,920	1,240	3,060	1,540	1,780	2,560
8	2,930	1,820	2,220	3,660	2,640	3,970	2,370	1,870	2,240	1,780	1,610	2,280
9	2,630	1,820	2,350	3,510	2,780	4,280	2,240	1,660	2,240	1,900	4,110	2,280
10	2,220	2,080	2,350	3,360	2,640	4,280	1,990	1,610	1,990	2,020	3,950	2,420
11	2,850	2,780	3,240	3,660	2,500	3,660	2,120	2,120	1,870	1,900	3,000	2,280
12	2,490	2,490	3,240	9,230	2,500	3,970	3,060	2,240	1,750	1,660	2,560	1,900
13	2,630	2,490	3,240	21,000	2,370	3,510	2,240	3,060	1,640	1,320	2,280	2,020
14	2,630	1,820	19,200	14,800	2,370	3,360	1,990	2,240	1,570	1,780	2,280	2,020
15	2,350	1,950	28,300	9,620	2,240	2,920	2,240	2,240	1,240	1,780	2,280	2,150
16	2,350	1,820	24,400	8,100	2,640	2,780	2,120	1,990	1,870	1,900	1,900	2,150
17	2,080	2,080	13,400	7,720	3,510	2,640	1,990	1,870	1,870	1,780	2,020	2,020
18	2,080	1,800	7,560	6,640	4,280	2,500	1,990	1,340	1,870	1,610	2,700	1,780
19	1,950	2,220	6,780	5,610	3,660	2,370	1,870	2,500	1,730	1,660	2,420	1,900
20	1,820	2,930	6,020	4,940	3,060	2,500	1,570	2,500	1,990	2,850	2,280	2,020
21	1,950	2,490	4,930	3,970	3,060	2,370	1,730	3,060	9,620	3,000	1,900	1,780
22	1,950	2,930	5,050	4,280	3,970	2,370	1,870	2,640	10,000	2,850	1,900	1,480
23	2,220	2,930	5,290	3,970	14,400	3,210	1,750	2,240	5,610	2,280	2,020	2,150
24	1,800	2,780	4,580	3,820	27,500	3,360	1,590	2,120	3,660	2,280	1,640	2,020
25	1,820	2,630	4,230	3,510	15,300	3,510	1,870	2,370	3,510	4,270	2,150	1,900
26	2,080	2,220	4,760	3,360	8,470	4,450	1,390	1,990	2,500	5,270	2,020	2,150
27	3,080	3,080	38,400	3,510	8,470	3,360	1,100	1,870	1,750	3,630	2,020	3,310
28	7,170	7,170	33,600	3,820	13,200	3,000	1,180	1,750	1,750	2,850	1,640	2,850
29	8,750	....	14,800	3,510	10,000	2,500	1,390	1,660	1,280	2,150	1,780	2,700
30	7,170	....	10,000	3,060	7,360	2,500	1,410	2,120	1,750	2,280	2,020	2,420
31	5,290	....	8,470	....	7,000	....	1,640	2,240	....	2,020	....	2,700
1914												
1	2,280	9,230	4,600	8,470	3,000	1,900	1,430	1,220	2,280	868	1,780	10,400
2	2,280	8,470	4,270	8,470	3,000	1,900	1,180	1,020	1,900	925	1,100	14,000
3	2,150	5,610	3,310	7,000	2,850	1,900	1,060	944	1,900	868	1,480	13,600
4	1,900	4,110	3,630	5,950	2,700	1,900	1,180	1,120	1,900	982	1,780	11,600
5	2,700	3,950	3,950	5,610	3,000	1,780	1,020	1,060	1,540	1,300	1,570	38,400

Daily discharge, in second-feet, of New River at Radford, Va., for 1906–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1914												
6	2,700	4,440	4,600	4,440	3,630	1,660	982	1,020	1,480	2,280	1,640	20,100
7	2,850	9,620	4,110	4,600	3,950	1,780	1,060	1,180	694	1,900	1,450	12,000
8	2,560	9,620	3,950	3,950	3,950	2,150	2,020	868	830	2,020	1,140	8,850
9	3,160	7,360	3,790	5,270	3,310	2,280	1,660	868	1,020	2,150	1,060	7,000
10	5,270	5,610	3,310	4,600	3,000	1,900	1,780	868	982	1,500	1,780	6,300
11	6,300	4,600	3,950	3,950	3,000	1,780	1,450	1,390	1,220	868	1,540	5,270
12	4,930	4,600	7,360	3,630	3,000	1,780	1,660	1,200	1,390	982	1,780	4,930
13	3,470	4,270	7,720	3,470	2,700	1,780	1,390	1,060	1,660	1,260	1,660	4,270
14	2,560	3,790	7,000	3,470	2,560	1,660	2,700	982	1,060	1,020	1,660	4,440
15	2,560	3,310	5,950	4,930	2,020	1,390	3,310	1,040	982	1,140	1,780	3,630
16	3,000	3,000	5,610	9,230	2,150	1,540	2,850	1,180	830	7,360	6,640	2,560
17	3,000	3,000	5,610	7,720	2,280	1,610	3,630	982	796	11,200	4,600	2,850
18	3,000	3,630	6,300	6,640	2,280	1,540	2,700	1,060	982	4,930	3,470	3,000
19	3,000	6,300	6,300	5,610	2,420	1,780	2,150	1,220	1,430	3,160	2,700	3,310
20	3,000	12,000	5,950	5,610	2,280	1,660	1,900	944	1,220	2,700	2,280	4,600
21	5,610	13,600	5,270	6,300	2,150	1,660	1,780	1,020	1,540	2,150	1,900	6,300
22	4,110	10,000	4,930	5,610	2,150	982	1,480	1,260	1,660	2,020	1,900	8,470
23	3,310	8,100	4,930	4,930	2,280	1,570	1,260	925	1,660	1,900	1,900	7,000
24	3,310	6,640	4,600	4,440	1,900	1,220	1,390	925	1,660	2,020	2,020	5,610
25	4,270	5,950	4,600	4,110	1,900	1,020	1,390	925	1,660	2,150	2,150	5,610
26	4,930	5,610	4,440	3,790	1,780	868	1,320	1,780	1,180	2,150	2,150	10,000
27	3,950	5,610	4,270	3,790	1,900	745	906	3,000	1,180	2,020	2,150	8,850
28	3,000	4,930	4,110	3,630	1,900	745	1,220	3,310	982	1,780	2,150	6,300
29	3,000	....	4,270	3,310	1,900	982	1,020	5,610	1,020	1,780	1,780	6,300
30	2,700	....	4,930	3,160	2,020	1,260	1,060	3,470	1,180	1,660	2,020	8,470
31	4,930	....	7,360	....	1,900	....	1,060	2,420	....	1,780	....	9,620

NOTE.—Discharge determined as follows: 1906 to Mar. 26, 1913, from a rating curve well defined between 800 and 17,000 second-feet and fairly well defined between 17,000 and 24,000 second-feet; above 24,000 second-feet curve is based on comparison of records with those on New River at Hinton, Kanawha Falls, and Charleston, and is poorly defined; Mar. 27 to Sept. 30, 1913, from a well-defined rating curve which differs from previous curves 5 to 7 per cent, the greatest difference being at high stage; Oct. 1, 1913, to Dec. 31, 1914, from a well-defined rating curve which is the same as previous curve above a discharge of 5,600 second-feet.

Discharge estimates above 16,000 second-feet 1906 to 1909 supersede those previously published in U. S. Geological Survey water-supply papers.

Discharge estimated, because of ice, from climatologic records, as follows: Jan. 7-20, 1912, 1,500 second-feet; Feb. 6-13, 1912, 1,800 second-feet. These estimates are based on insufficient data and should therefore be used with caution.

Monthly discharge of New River at Radford, Va., for 1898–1914.

[Drainage area, 2,720 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1898						
August	14,230	2,710	4,747	1.74	2.01	
September	27,800	2,160	5,720	2.10	2.34	
October	46,100	3,000	9,050	3.33	3.84	
November	5,260	3,000	4,117	1.51	1.68	
December	10,770	3,590	5,228	1.92	2.21	

Monthly discharge of New River at Radford, Va., for 1898–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1899						
January	16,900	3,900	5,890	2.17	2.50	
February	24,900	3,590	11,500	4.23	4.40	
March	49,200	7,160	16,400	6.03	6.95	
April	17,400	4,550	8,041	2.95	3.29	
May	8,740	3,590	5,697	2.09	2.41	
June	16,400	2,430	4,800	1.76	1.96	
July	4,550	1,640	2,452	.900	1.04	
August	4,550	1,150	2,192	.804	.93	
September	6,770	510	2,717	.997	1.11	
October	1,640	510	1,107	.406	.47	
November	4,550	510	1,376	.505	.56	
December	19,200	700	3,140	1.15	1.33	
The year	49,200	510	5,400	1.99	26.95	
1900						
January	12,470	250	3,933	1.44	1.66	
February	20,600	2,430	6,920	2.54	2.64	
March	26,400	5,260	10,200	3.75	4.32	
April	16,900	3,590	6,700	2.46	2.74	
May	8,340	3,900	4,730	1.74	2.01	
June	8,340	3,590	5,094	1.87	2.09	
July	8,740	1,640	3,082	1.13	1.30	
August	2,710	120	1,242	.456	.53	
September	11,820	170	2,220	.815	.91	
October	117,000	700	7,170	2.64	3.04	
November	35,300	2,430	5,590	2.06	2.30	
December	16,900	3,290	5,760	2.12	2.44	
The year	117,000	120	5,210	1.92	25.98	
1901						
January	16,900	2,710	4,640	1.71	1.97	
February	6,380	1,390	3,696	1.36	1.42	
March	21,500	360	4,680	1.72	1.98	
April	92,200	4,220	15,300	5.62	6.27	
May	117,000	4,550	15,900	5.85	6.74	
June	38,400	6,000	13,500	4.96	5.53	
July	19,600	4,550	8,490	3.12	3.60	
August	57,600	4,220	20,200	7.43	8.57	
September	22,700	4,220	8,030	2.95	3.29	
October	12,470	2,710	4,952	1.82	2.10	
November	5,260	1,640	2,500	.917	1.02	
December	98,000	1,900	15,200	5.59	6.44	
The year	117,000	360	9,810	3.61	48.93	
1902						
January	16,900	4,220	6,770	2.49	2.87	
February	57,100	3,900	10,400	3.82	3.98	
March	57,100	4,550	10,400	3.82	4.40	
April	9,140	3,900	6,041	2.22	2.48	
May	4,550	1,150	2,707	.993	1.14	
June	18,700	2,430	6,220	2.29	2.56	
July	9,950	3,000	4,666	1.71	1.97	
August	5,630	1,640	3,729	1.37	1.58	
September	?,290	1,150	1,919	.704	.785	
October	4,220	1,390	2,391	.877	1.01	
November	5,260	1,150	2,452	.900	1.00	
December	6,000	2,160	3,450	1.27	1.46	
The year	57,100	1,150	5,060	1.86	25.23	

Monthly discharge of New River at Radford, Va., for 1898–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1903						
January	20,100	2,710	5,610	2.06	2.38	
February	40,400	4,220	8,400	3.09	3.22	
March	42,000	4,220	11,900	4.38	5.05	
April	16,900	6,000	9,390	3.45	3.85	
May	6,770	3,000	4,342	1.59	1.83	
June	18,300	3,000	6,380	2.35	2.62	
July	8,340	2,430	4,578	1.68	1.94	
August	9,950	2,160	3,949	1.45	1.67	
September	14,230	1,390	2,793	1.02	1.14	
October	6,000	1,150	2,232	.819	.94	
November	3,290	920	2,081	.764	.85	
December	2,430	510	1,453	.533	.62	
The year	42,000	510	5,230	1.92	26.11	
1904						
January	8,340	510	2,184	0.801	0.92	
February	7,940	1,150	3,208	1.18	1.27	
March	16,900	1,390	4,480	1.65	1.90	
April	3,900	1,900	2,775	1.02	1.14	
May	12,040	2,160	4,149	1.52	1.75	
June	12,900	510	3,940	1.45	1.62	
July	5,630	1,390	2,876	1.06	1.22	
August	5,630	1,390	3,010	1.10	1.27	
September	2,710	1,150	1,484	.545	.608	
October	1,150	700	835	.306	.353	
November	2,430	920	1,402	.514	.573	
December	3,590	920	1,648	.608	.695	
The year	16,900	510	2,660	.978	13.32	
1905						
January	9,540	1,640	2,777	1.02	1.18	
February	18,700	1,640	4,500	1.65	1.72	
March	9,950	2,160	4,435	1.63	1.88	
April	5,260	1,640	2,763	1.01	1.13	
May	23,400	1,640	6,290	2.31	2.66	
June	2,710	920	1,588	.583	.65	
July	90,800	1,150	9,040	3.32	3.83	
August	11,190	920	4,766	1.75	2.02	
September	7,550	1,640	2,885	1.06	1.18	
October	2,710	1,390	1,805	.662	.76	
November	1,900	1,390	1,610	.591	.66	
December	11,610	1,150	4,312	1.58	1.82	
The year	90,800	920	3,910	1.44	19.49	
1906						
January	30,800	2,160	7,960	2.93	3.38	
February	7,160	2,430	3,930	1.44	1.50	
March	14,200	3,290	5,230	1.92	2.21	
April	11,600	2,430	4,550	1.67	1.86	
May	5,260	2,430	3,100	1.14	1.31	
June	10,800	2,160	3,970	1.46	1.63	
July 1–15	2,710	2,160	2,310	.849	.47	
1907						
May 6–31	13,800	2,430	3,620	1.33	1.29	B.
June	52,900	1,640	8,470	3.11	3.47	B.
July	5,630	2,160	3,530	1.30	1.50	A.
August	4,550	1,900	2,510	.923	1.06	A.
September	35,800	1,640	5,190	1.91	2.13	A.
October	3,900	1,640	2,210	.812	.94	A.
November	8,340	2,430	4,120	1.51	1.68	A.
December	16,900	2,160	5,920	2.18	2.51	A.

Monthly discharge of New River at Radford, Va., for 1898–1914—Continued.

Month	Discharge in second-feet: Maximum	Minimum	Mean	Per square mile	Run-off (depth in inches on drainage area)	Accuracy
1908						
January	38,400	3,900	8,190	3.01	3.47	A.
February	32,800	2,710	9,540	3.51	3.79	A.
March	14,200	3,900	7,300	2.68	3.09	A.
April	20,100	3,590	6,630	2.44	2.72	A.
May	11,000	3,900	5,500	2.02	2.33	A.
June	19,600	3,290	5,260	1.93	2.15	A.
July	7,940	2,710	4,480	1.65	1.90	A.
August	19,600	2,160	4,450	1.64	1.89	A.
September	6,380	1,640	2,710	.996	1.11	A.
October	22,500	1,640	5,960	2.19	2.52	A.
November	9,540	3,290	4,880	1.79	2.00	A.
December	14,200	3,590	5,860	2.15	2.48	A.
The year	38,400	1,640	5,890	2.17	29.45	
1909						
January	17,400	3,290	6,880	2.53	2.92	A.
February	12,000	2,160	5,720	2.10	2.19	A.
March	9,140	3,900	5,600	2.06	2.38	A.
April	20,600	3,290	5,300	1.95	2.18	A.
May	38,400	3,290	8,510	3.13	3.61	A.
June	19,200	4,220	6,320	2.32	2.59	A.
July	6,380	2,160	3,550	1.31	1.51	A.
August	7,550	920	2,860	1.05	1.21	A.
September	3,900	1,150	2,170	.798	.89	A.
October	10,800	1,390	2,540	.934	1.08	A.
November	2,160	1,390	1,610	.592	.66	A.
December	8,340	1,150	2,250	.827	.95	A.
The year	38,400	920	4,440	1.63	22.17	
1910						
January	6,020	1,580	3,100	1.14	1.31	A.
February	21,500	960	4,690	1.72	1.79	A.
March	9,970	1,950	3,440	1.26	1.45	A.
April	5,650	1,580	2,770	1.02	1.14	A.
May	4,930	1,820	2,750	1.01	1.16	A.
June	27,800	1,580	6,830	2.51	2.80	A.
July	6,590	1,150	3,490	1.28	1.48	A.
August	2,350	1,360	1,850	.680	.78	A.
September	7,760	1,150	2,560	.941	1.05	A.
October	11,000	620	2,310	.849	.98	A.
November	1,820	1,150	1,570	.577	.64	A.
December	5,290	700	1,940	.713	.82	A.
The year	27,800	620	3,090	1.14	15.40	
1911						
January	15,600	1,820	4,520	1.66	1.91	B.
February	10,600	2,080	3,940	1.45	1.51	B.
March	10,600	1,820	4,070	1.50	1.73	B.
April	20,100	3,400	7,460	2.74	3.06	B.
May	6,210	1,470	3,070	1.13	1.30	B.
June	3,890	1,360	2,160	.794	.89	A.
July	5,110	888	1,620	.596	.69	A.
August	5,360	550	1,660	.610	.70	A.
September	5,400	578	1,680	.618	.69	B.
October	20,200	1,150	2,860	1.05	1.21	C.
November	2,630	764	1,870	.688	.77	B.
December	9,270	816	3,840	1.41	1.63	B.
The year	20,200	550	3,220	1.18	16.09	

Monthly discharge of New River at Radford, Va., for 1898–1914—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1912						
January	7,950	....	2,830	1.04	1.20	D.
February	16,400	....	4,450	1.64	1.77	C.
March	27,300	4,200	9,030	3.32	3.83	C.
April	13,800	3,560	5,530	2.03	2.26	B.
May	25,400	3,400	6,310	2.32	2.68	C.
June	4,930	1,950	2,990	1.10	1.23	B.
July	6,780	1,630	3,060	1.12	1.25	B.
August	5,650	1,360	2,420	.890	1.03	B.
September	11,200	1,110	2,560	.941	1.05	B.
October	2,080	1,110	1,670	.614	.70	B.
November	4,930	908	1,990	.732	.82	B.
December	2,780	1,150	1,800	.662	.76	B.
The year	27,300	....	3,720	1.37	18.63	
1913						
January	8,750	1,800	3,090	1.14	1.31	B.
February	7,170	1,800	2,810	1.03	1.07	B.
March	38,400	2,220	9,330	3.43	3.95	B.
April	21,000	3,060	5,740	2.11	2.35	A.
May	27,500	2,240	5,670	2.08	2.40	A.
June	7,000	2,370	3,570	1.31	1.46	A.
July	5,950	1,100	2,350	.864	1.00	A.
August	3,060	1,160	1,970	.724	.83	B.
September	10,000	1,280	2,790	1.03	1.15	A.
October	5,270	1,320	2,210	.812	.94	A.
November	4,110	1,610	2,180	.801	.89	A.
December	4,440	1,480	2,370	.871	1.00	A.
The year	38,400	1,100	3,680	1.35	18.35	
1914						
January	6,300	1,900	3,410	1.25	1.44	B.
February	13,600	3,000	6,320	2.32	2.42	B.
March	7,720	3,310	5,000	1.84	2.12	A.
April	9,230	3,160	5,190	1.91	2.13	A.
May	3,950	1,780	2,540	.934	1.08	A.
June	2,280	745	1,560	.574	.64	A.
July	3,630	906	1,650	.607	.70	A.
August	5,610	868	1,480	.544	.63	A.
September	2,280	694	1,330	.489	.55	A.
October	11,200	868	2,280	.838	.97	A.
November	6,640	1,060	2,100	.772	.86	A.
December	38,400	2,560	8,500	3.12	3.60	A.
The year	38,400	694	3,480	1.28	17.14	

NOTE.—Discharge estimates above 16,000 second-feet for years previous to 1910 have been revised and, as published herewith, supersede those published in Bulletin III, Hydrography of Virginia, and in U. S. Geological Survey water-supply papers.

Discharge estimates from August to December, 1899, July, 1900, the year 1902, and January to August, 1903, subject to errors due to errors in gage and inaccuracies in gage readings. Ice present Jan. 1-9, 1900, and Jan. 26-29, 1905, but no correction was made in estimates. Jan. 5 and 6, 1905, water was thrown from gage by ice and discharge estimates were corrected. See footnote to daily discharge table for estimates for period during 1912 when discharge relation was affected by ice.

NEW RIVER AT FAYETTE, W. VA.

Location.—At the highway bridge connecting Fayette and South Fayette, 850 feet above mouth of Wolf Creek.

Drainage area.—6,800 square miles.

Records available.—July 16, 1908, to December 31, 1914. Records July 29, 1895, to May 22, 1901, and August 11, 1902, to December 31, 1904, obtained by United States Geological Survey, but computed results for these periods are only fair and are not included in this report.

Gage.—Chain attached to the bridge; read twice daily; wire gage used previous to November 20, 1903.

Discharge measurements.—Made from the bridge.

Channel and control.—Banks high and not subject to overflow. Bed composed of rock strewn with large bowlders, which cause boils and eddies at high stages. Control practically permanent.

Extremes of stage.—Flood of 1878 reached a height of about 53 feet referred to the gage datum. Maximum stage recorded since reëstablishment in 1908: 36.5 feet, March 28, 1913. Minimum stage recorded since 1908: —0.4 foot, October 7, 1914.

Winter flow.—Discharge relation little if at all affected by ice.

Accuracy.—Gage heights previous to 1908, and particularly those observed with a wire gage, subject to considerable error.

Computation of discharge for years since 1908 and revisions for previous years withheld because of insufficient data.

Discharge measurements of New River at Fayette, W. Va., in 1908–1914.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
1908			
Aug. 13	W. G. Hoyt	[a]3.24	4,780
Aug. 14	do	[b]3.09	4,270
Sept. 19	W. M. O'Neill	1.32	2,540
Sept. 21	do	[c]1.50	2,730
Sept. 21	do	1.24	2,530
1909			
Apr. 2	H. J. Jackson	6.94	13,000
Apr. 14	do	[d]8.11	17,100
June 26	do	4.24	6,820
Nov. 20	A. H. Horton	1.30	2,660
Nov. 20	do	1.30	2,680
Dec. 1	G. L. Parker	1.10	2,390
1910			
Mar. 7	Horton and Bailey	6.88	13,000
Mar. 7	do	6.90	12,900
Mar. 28	C. T. Bailey	2.68	4,340
June 18	H. J. Jackson	16.02	46,700
June 18	do	14.68	40,900
June 19	do	11.17	26,800
June 19	H. J. Jackson	10.72	25,200
June 20	do	9.62	21,500
June 20	do	9.05	19,300
Oct. 12	C. T. Bailey	3.72	5,420
1912			
Mar. 26	C. T. Bailey	13.15	35,100
Sept. 10	do	.48	2,070
1913			
Mar. 28	A. H. Horton	[e]33.2	[f]147,000
June 19	H. J. Jackson	3.10	4,690
Nov. 15	Peterson and Walters	6.05	10,400
1914			
Oct. 26	Mathers and Morgan	1.17	2,510
Nov. 9	do	.15	1,710
Nov. 10	do	.31	1,780

[a] Stage fell 0.5 foot during measurement.
[b] Gage height fell 1.78 feet during measurement.
[c] Gage height is approximate.
[d] Gage height rose 0.72 foot during measurement.
[e] $\pm$ 0.5 foot.
[f] Velocities for this measurement determined by means of surface floats. A coefficient of 0.85 was used to reduce the observed velocities to mean velocities.

Daily gage height, in feet, of New River at Fayette, W. Va., for 1908–1914.

[J. R. Durrett, A. E. Pierson, and C. J. Henry, observers.]

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908							1908						
1	......	3.82	3.24	2.22	10.27	2.78	16	......	2.10	1.56	1.44	2.72	5.86
2	......	3.72	2.91	1.87	7.60	2.76	17	......	2.10	1.48	1.38	2.42	5.08
3	......	3.52	2.58	1.50	6.40	2.78	18	......	2.08	1.42	1.34	2.55	4.70
4	......	2.81	2.28	1.22	6.16	2.98	19	......	2.06	1.35	1.31	3.04	4.36
5	......	2.28	2.08	1.07	5.48	3.45	20	2.32	2.14	1.26	1.36	2.82	4.61
6	......	2.16	2.44	.95	4.24	3.32	21	2.42	2.04	1.20	1.38	2.62	4.54
7	......	2.11	3.12	.93	3.86	3.19	22	2.22	1.90	1.17	1.34	2.50	4.36
8	......	2.65	3.65	.95	4.22	3.38	23	2.26	1.69	1.06	1.32	3.45	4.44
9	......	4.44	3.65	.94	4.52	4.48	24	2.64	1.68	1.08	1.37	3.65	4.30
10	......	4.94	3.72	.96	4.49	......	25	3.98	3.62	1.06	12.38	3.42	5.09
11	......	4.58	2.87	1.30	3.48	......	26	3.88	2.88	1.01	9.09	3.20	8.04
12	......	3.92	2.35	7.20	2.34	......	27	3.72	9.76	.96	6.92	3.02	8.10
13	......	3.43	1.98	4.71	2.10	7.90	28	5.54	7.78	.94	5.35	2.92	7.80
14	......	2.84	1.80	3.12	2.60	7.48	29	5.78	6.42	1.02	4.66	2.85	7.54
15	......	2.30	1.63	1.70	3.11	6.82	30	4.88	4.96	1.19	7.22	2.81	8.00
							31	4.08	3.70	......	11.36	......	11.02

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	12.32	4.28	7.36	7.62	13.32	6.40	5.42	3.66	0.58	1.39	1.38	1.10
2	9.86	3.15	6.76	7.04	13.62	6.24	5.96	3.68	.68	1.17	1.29	1.12
3	8.18	2.98	7.32	7.54	10.98	5.42	5.92	5.21	.84	1.11	1.22	1.02
4	7.14	3.52	8.25	6.12	9.16	4.99	5.45	5.32	1.03	1.06	1.17	1.02
5	6.94	4.50	8.46	5.76	7.28	8.72	4.12	4.10	1.10	.89	1.14	.98
6	12.81	4.60	8.38	5.64	6.63	9.61	10.62	3.93	1.10	.93	1.12	.95
7	12.85	4.59	10.30	5.78	6.08	7.40	12.95	3.52	1.12	.95	1.12	1.15
8	9.75	4.20	11.05	5.25	5.66	6.18	8.20	3.08	1.17	.87	1.00	1.10
9	8.19	4.69	12.45	4.50	5.42	6.55	6.40	3.43	1.45	.96	1.00	1.35
10	6.76	6.52	12.20	4.68	7.01	7.65	5.70	3.16	3.01	.97	.90	1.80
11	6.05	11.55	11.24	4.39	10.02	7.55	4.95	2.31	3.33	1.95	.90	2.30
12	5.16	11.60	10.38	4.20	10.38	7.26	4.25	2.03	2.91	4.27	.90	1.95
13	5.07	8.65	8.55	4.12	8.76	6.06	4.05	1.90	2.35	7.82	2.20	2.05
14	5.88	7.49	7.92	6.78	7.16	5.80	3.92	1.83	2.06	5.65	1.83	3.65
15	6.10	7.16	7.60	16.62	6.10	5.88	3.60	2.34	1.27	4.12	1.78	9.68
16	6.74	7.00	7.09	11.72	5.45	5.48	3.50	3.06	1.47	3.91	1.74	7.25
17	12.19	8.08	6.58	8.76	4.98	5.10	3.26	3.53	1.79	3.10	1.69	5.50
18	10.94	9.26	6.10	7.58	4.57	5.26	3.09	4.02	3.15	3.08	1.58	4.25
19	10.19	8.85	5.50	6.70	4.14	5.22	2.79	4.02	5.25	2.82	1.54	3.25
20	9.28	7.74	5.19	6.12	3.95	5.20	2.69	3.30	5.76	2.52	1.16	2.65
21	8.54	8.10	5.58	5.91	4.12	4.78	2.38	2.40	5.29	2.18	1.21	2.00
22	8.02	8.20	6.36	6.55	10.45	4.22	2.14	1.92	4.99	2.12	1.20	1.80
23	7.75	9.20	6.59	7.48	12.14	3.85	2.02	1.80	3.13	2.10	1.40	1.15
24	7.36	9.20	7.02	8.54	8.54	3.58	2.08	1.73	2.05	2.30	1.35	.75
25	7.22	10.70	8.28	8.91	7.98	4.56	2.19	1.58	3.03	2.24	1.50	1.10
26	7.10	11.20	12.22	7.68	7.82	4.34	2.09	1.53	2.88	2.05	1.30	1.85
27	6.58	9.20	11.20	6.36	11.66	4.02	2.05	1.39	2.85	1.88	1.45	1.30
28	6.12	8.32	10.75	6.10	11.14	4.79	2.18	1.28	2.18	1.74	1.40	1.35
29	5.68	....	10.90	7.70	8.86	4.84	2.19	1.08	1.86	1.66	1.60	1.35
30	5.20	....	10.85	6.25	7.20	5.26	2.79	1.08	1.47	1.58	1.20	1.30
31	4.90	....	9.20	....	6.66	....	3.32	.97	....	1.47	....	.70
1910												
1	0.45	3.80	7.95	2.35	5.42	3.60	3.68	2.10	1.45	2.08	1.11	2.38
2	1.68	3.45	12.32	2.25	4.90	3.05	3.39	2.00	2.42	1.68	1.22	2.00
3	3.32	3.42	11.45	2.22	4.35	2.75	3.14	1.92	5.76	1.48	1.19	1.85
4	5.32	4.55	9.70	2.85	3.95	2.48	4.42	1.75	4.90	1.22	1.11	1.28
5	7.05	5.62	8.15	3.77	3.60	2.70	5.66	1.82	4.50	1.08	1.09	1.08

Daily gage height, in feet, of New River at Fayette, W. Va., for 1908–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
6	5.95	5.42	7.12	4.28	3.34	7.35	5.70	1.94	4.32	.94	1.00	1.86
7	8.88	4.96	6.85	3.65	3.15	8.25	5.78	2.10	4.12	.84	1.04	2.90
8	10.20	3.52	6.78	3.15	3.24	6.95	5.86	2.04	3.50	.96	1.05	3.82
9	9.15	3.60	6.35	2.85	3.69	5.55	5.69	1.80	2.98	2.88	.90	4.00
10	6.95	4.22	5.78	2.58	4.20	4.78	5.99	1.73	2.55	5.85	.76	3.00
11	5.05	4.30	5.48	2.38	4.84	5.70	5.82	1.82	2.20	4.90	.74	2.50
12	4.12	4.10	5.25	2.48	4.98	9.40	4.64	1.54	2.00	3.62	.80	2.18
13	3.55	3.25	5.18	3.58	4.72	14.15	4.18	1.38	1.92	2.72	.76	2.20
14	3.78	3.08	5.38	5.35	4.62	19.00	5.08	1.19	1.94	2.25	.72	1.80
15	3.98	3.28	5.28	6.12	4.82	16.35	6.32	1.15	1.84	1.92	.72	1.30
16	3.55	4.30	4.95	5.39	4.39	14.95	5.68	1.22	1.76	1.64	.62	1.02
17	3.20	7.32	4.70	4.61	3.90	21.95	4.95	1.35	1.55	1.48	.72	.55
18	3.25	11.20	4.08	5.02	3.62	15.94	7.82	1.26	1.36	1.28	.85	.30
19	7.18	15.30	3.82	6.15	3.72	11.16	9.48	1.24	1.19	1.10	.94	1.60
20	7.80	10.92	3.58	6.30	3.82	9.19	7.70	1.12	1.06	1.10	.84	1.78
21	8.28	8.45	3.42	6.42	3.85	8.90	5.75	.92	.92	1.08	.89	1.50
22	13.32	7.50	3.26	7.08	3.80	7.64	4.58	.92	.90	1.38	.78	1.25
23	11.72	7.90	3.18	6.52	3.84	7.44	3.86	1.26	.88	1.78	.62	.70
24	8.55	7.95	3.15	7.16	3.95	7.06	3.40	1.18	.81	1.81	.66	2.00
25	6.90	6.98	2.95	7.10	4.30	7.02	3.19	1.32	.72	1.54	.66	2.00
26	6.02	6.05	2.75	6.85	4.82	6.22	2.94	1.60	.82	1.31	.62	2.62
27	5.48	5.40	2.78	6.40	5.22	6.02	2.52	1.42	.71	1.24	.60	2.68
28	5.48	5.08	2.66	6.60	4.90	5.04	2.32	1.80	1.48	1.18	1.28	3.65
29	5.15	....	2.55	6.46	4.22	4.42	2.18	1.40	1.98	1.18	1.90	3.58
30	4.48	....	2.46	6.20	4.00	4.08	2.04	1.35	2.34	1.11	2.25	5.00
31	4.08	....	2.39	....	4.10	....	2.00	1.22	....	1.16	....	9.62
1911												
1	8.15	13.55	3.76	6.93	5.45	2.37	1.85	0.09	3.05	0.65	2.08	3.45
2	12.50	11.23	3.90	6.78	5.72	2.42	1.50	.06	4.60	.85	1.82	3.28
3	14.75	9.45	3.78	8.00	5.55	2.57	1.23	.04	4.35	5.60	1.68	2.95
4	18.10	7.92	3.68	12.18	5.29	2.38	1.10	.02	3.55	4.90	1.35	2.82
5	14.40	7.82	3.48	14.20	4.82	2.34	1.24	.00	2.20	3.50	1.18	2.62
6	10.68	7.70	9.33	17.68	4.43	2.46	1.97	.12	1.72	2.60	3.02	2.42
7	7.60	6.70	13.78	16.42	4.17	2.68	1.73	1.52	1.48	2.05	6.20	2.25
8	6.15	5.48	10.86	14.62	3.95	2.58	1.97	2.55	1.30	2.15	9.72	2.24
9	5.45	6.88	10.06	14.52	3.72	3.20	2.53	1.95	.92	2.20	8.52	2.20
10	5.42	8.48	11.40	14.27	3.55	3.16	3.32	1.50	.78	3.75	5.78	2.05
11	5.15	11.78	13.60	10.97	3.52	2.66	2.93	1.28	1.38	3.40	4.88	2.02
12	4.42	9.26	11.83	9.22	3.39	2.21	2.73	1.05	1.72	3.50	4.58	2.00
13	3.52	8.13	10.18	8.19	3.29	2.06	2.23	.85	1.78	3.10	4.58	1.90
14	3.62	6.73	8.58	7.95	3.15	2.16	1.95	2.38	1.60	2.80	4.54	1.98
15	6.55	5.98	8.50	8.87	4.09	1.61	1.70	2.05	1.25	2.40	4.48	1.95
16	5.60	5.33	7.68	12.59	4.85	1.51	1.65	1.60	1.05	2.35	4.38	2.20
17	5.38	4.78	6.90	12.45	4.07	1.26	1.65	1.38	1.05	3.95	4.80	2.70
18	5.25	4.38	6.33	9.87	3.39	1.24	1.37	1.18	3.15	11.00	4.20	3.80
19	4.92	4.20	6.56	8.47	2.99	1.28	1.20	.90	2.50	18.05	4.65	4.75
20	4.68	5.78	7.58	8.37	2.77	1.44	.95	.55	1.85	10.65	6.00	4.45
21	4.82	6.03	7.40	9.97	2.55	1.61	.70	.38	1.20	7.50	5.23	3.38
22	5.70	5.58	6.90	9.92	2.42	1.84	.63	.15	1.00	6.65	4.60	3.05
23	6.65	5.06	6.63	8.92	2.31	1.78	.53	.06	.90	4.75	3.90	3.62
24	8.70	4.56	6.00	8.02	2.21	1.74	.40	.12	1.00	4.65	3.50	10.20
25	7.60	4.18	5.38	7.35	2.29	1.66	.42	.25	1.55	4.45	3.75	9.90
26	6.65	4.10	4.88	6.45	2.21	1.58	.27	.38	1.55	3.85	3.65	9.40
27	6.55	3.98	4.50	5.99	2.11	1.78	.23	.38	1.15	3.30	3.85	9.85
28	7.05	3.90	6.50	5.52	2.03	2.11	.15	.22	1.05	3.38	3.55	9.50
29	8.55	....	7.42	5.35	1.81	2.04	.05	.30	.90	3.55	3.65	9.15
30	16.35	....	7.08	5.35	2.07	2.51	.10	1.60	.65	2.18	3.55	8.20
31	19.58	....	6.93	....	2.18	....	.08	1.85	....	2.28	....	7.30

Daily gage height, in feet, of New River at Fayette, W. Va., for 1908–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	7.6	8.9	8.6	12.2	8.4	3.7	7.0	2.1	1.4	2.5	0.7	0.8
2	8.6	7.4	7.8	15.0	7.8	3.5	5.2	1.9	1.4	2.2	.5	.9
3	8.0	5.9	8.0	17.8	6.7	3.1	5.2	2.2	1.5	1.6	.5	1.0
4	6.6	3.6	9.0	14.9	6.0	2.9	4.8	2.0	1.5	1.5	.5	1.0
5	5.3	3.0	8.2	11.2	5.4	3.1	4.7	1.9	1.5	1.4	.6	1.7
6	4.1	2.6	4.7	9.3	5.2	3.1	6.3	1.9	1.4	1.3	.6	2.0
7	2.6	2.9	5.0	8.2	5.8	2.9	6.5	2.2	1.3	1.4	1.3	2.7
8	2.1	2.8	5.8	7.7	6.4	2.6	5.2	2.0	1.1	1.4	3.4	3.2
9	2.1	3.4	8.1	7.2	6.2	2.6	5.0	1.6	.9	1.3	8.0	3.6
10	2.1	3.4	10.6	6.7	5.7	2.6	4.4	1.4	.8	1.2	5.6	3.1
11	2.1	3.2	9.5	6.2	5.2	2.4	4.0	1.5	.5	1.1	4.5	2.9
12	2.2	3.1	9.2	5.8	10.2	2.0	4.0	1.5	.7	1.0	4.0	2.2
13	3.1	3.0	17.3	5.3	19.1	1.9	4.1	1.5	.6	.9	2.8	2.0
14	2.9	3.2	15.6	5.2	14.2	1.8	4.1	1.4	.4	.5	3.2	1.9
15	2.9	2.6	15.2	5.0	10.4	1.8	4.3	1.4	.3	.4	2.4	1.6
16	2.2	2.6	24.7	5.0	12.3	1.9	4.0	1.2	.3	.5	1.9	1.5
17	1.8	2.6	19.2	5.0	17.8	2.3	3.6	1.0	.5	.5	1.9	1.2
18	1.7	2.9	14.0	5.6	14.6	2.6	3.5	1.1	.8	.5	1.7	1.2
19	3.5	3.1	11.6	6.1	10.2	2.9	2.9	1.3	1.0	.6	1.4	1.4
20	9.7	3.8	9.8	6.3	8.7	2.9	2.5	1.5	1.5	.8	1.4	1.4
21	6.5	5.1	8.8	5.7	7.5	2.8	2.5	1.5	1.9	.8	1.4	1.3
22	5.8	11.3	8.4	5.1	6.6	2.3	3.0	2.2	1.8	1.1	1.4	1.2
23	5.7	15.2	9.6	5.0	5.8	2.1	3.2	2.2	2.2	1.4	1.2	1.3
24	5.6	10.5	9.8	5.2	5.2	2.4	2.8	2.0	3.8	1.6	1.2	1.2
25	5.5	8.6	13.0	5.4	4.8	3.8	3.8	1.6	8.0	1.5	.9	1.2
26	5.2	8.5	13.2	5.0	4.5	5.8	3.7	1.5	7.0	1.3	.9	1.3
27	5.2	10.6	11.0	5.7	4.3	5.6	5.6	1.4	5.5	1.0	1.0	1.3
28	5.3	14.4	9.2	9.6	4.0	8.3	4.6	1.4	4.9	.8	1.0	1.5
29	5.6	10.8	14.0	8.6	3.9	7.7	4.2	1.4	3.0	.8	.9	2.0
30	10.4	....	23.2	8.6	3.6	6.0	3.4	1.2	2.7	.8	.9	2.2
31	10.4	....	16.1	....	3.7	....	2.0	1.3	....	.8	....	....
1913												
1	3.0	8.9	8.4	8.9	4.5	9.6	2.3	1.0	1.2	3.8	2.0	6.7
2	9.4	9.4	8.7	6.3	3.8	7.6	2.7	.9	1.6	3.9	1.1	6.8
3	7.4	9.3	7.6	5.8	4.0	6.4	3.0	.8	1.5	4.0	1.2	7.0
4	6.9	9.0	5.9	5.0	3.9	6.2	3.1	.7	1.4	4.1	1.3	7.0
5	8.2	8.8	6.0	4.8	3.7	9.0	3.1	.6	1.1	4.2	1.4	6.5
6	7.9	8.3	5.9	4.9	3.5	6.8	3.1	.5	1.1	4.1	1.4	7.8
7	11.4	8.2	5.1	4.7	3.7	6.1	3.1	.5	1.1	4.2	1.5	7.4
8	17.9	7.9	4.7	4.6	3.6	6.5	3.0	.7	1.2	4.4	1.5	7.4
9	11.8	7.5	4.8	4.4	3.5	7.7	2.8	1.1	1.2	4.8	1.6	7.3
10	9.8	3.9	4.9	3.7	3.0	6.8	2.8	1.1	1.3	5.2	1.7	7.1
11	9.1	3.2	4.2	4.2	3.7	5.9	2.8	1.1	1.3	5.4	1.7	6.9
12	9.8	3.1	6.0	4.2	2.6	5.5	2.9	1.1	1.1	5.9	1.8	6.3
13	6.8	3.1	6.7	13.0	2.8	4.6	3.0	1.2	1.0	6.1	2.2	6.0
14	6.6	3.0	7.5	17.4	2.7	4.6	3.0	1.2	.6	5.2	4.5	5.5
15	6.1	3.0	15.0	14.2	2.6	4.5	3.0	1.2	1.1	4.8	7.3	5.8
16	5.3	2.7	17.2	13.6	2.7	3.3	3.0	1.1	1.1	4.3	7.4	7.7
17	4.6	2.8	10.7	11.6	2.7	4.2	2.8	1.1	1.0	3.6	7.4	8.3
18	4.1	2.7	8.6	9.7	3.4	3.5	2.6	1.1	1.1	2.5	7.8	8.0
19	4.3	2.4	7.4	8.1	4.1	3.1	2.3	1.1	1.5	2.1	7.1	7.8
20	4.1	2.2	7.0	6.8	3.9	2.9	2.2	1.1	1.6	1.8	6.9	7.0
21	3.7	2.5	7.3	6.5	4.2	2.9	2.2	1.2	1.5	1.4	6.3	5.1
22	3.3	2.8	7.5	5.7	4.8	2.9	2.2	1.1	3.4	1.2	6.0	3.1
23	2.8	2.9	7.4	5.3	5.1	2.6	2.2	1.1	7.0	1.1	5.5	3.1
24	5.0	3.1	5.1	5.0	11.8	2.5	2.2	1.1	6.3	1.1	5.3	3.1
25	4.8	2.9	4.7	4.7	16.3	3.0	1.9	1.1	4.7	1.0	5.1	3.0

Daily gage height, in feet, of New River at Fayette, W. Va., for 1908–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
26	4.2	2.9	4.9	4.5	11.5	3.7	1.9	1.1	4.1	1.6	5.1	3.0
27	5.4	2.4	19.7	4.6	10.1	3.5	1.8	1.1	4.0	1.8	5.1	2.9
28	8.2	5.4	31.0	4.7	13.7	3.8	1.7	1.1	4.2	2.0	5.0	2.8
29	9.6	....	20.5	4.7	14.3	3.3	1.1	1.1	4.2	2.4	5.0	2.7
30	9.4	....	11.6	4.7	10.9	3.0	1.0	1.1	4.5	2.2	6.6	2.6
31	9.1	....	10.2	....	9.1	....	1.0	1.1	....	2.0	....	3.5
1914												
1	3.9	5.2	5.0	5.5	5.1	5.0	1.2	4.3	5.1	0.0	1.0	1.2
2	3.9	5.2	4.9	5.6	5.1	4.8	1.1	4.4	5.0	.0	1.3	4.4
3	4.0	5.5	4.8	5.6	5.0	4.7	1.0	4.4	5.0	.0	1.0	8.7
4	5.3	6.0	4.7	5.5	5.0	4.7	.9	4.5	4.9	−.3	.4	9.0
5	6.8	6.1	3.8	5.4	4.9	4.5	.8	4.6	4.8	−.3	.5	9.6
6	7.4	6.3	4.0	5.3	4.7	4.4	.8	4.9	4.8	−.3	.2	23.0
7	7.9	6.3	5.1	5.2	4.7	4.3	.9	5.0	4.8	−.4	.3	12.2
8	8.0	5.4	5.2	5.0	4.6	4.2	.8	5.1	4.8	1.0	.4	9.5
9	8.1	4.1	5.8	4.8	4.4	4.2	1.1	5.2	4.7	.9	.2	8.3
10	8.2	4.1	6.0	4.8	4.3	4.1	1.2	5.2	4.6	.8	.2	7.6
11	8.3	4.0	7.0	4.8	4.1	4.1	1.2	5.4	4.5	.8	.1	6.0
12	8.5	4.0	7.1	4.7	4.1	4.1	1.4	5.5	4.5	.7	.2	5.2
13	8.4	4.1	7.2	4.7	4.3	4.0	1.9	5.6	4.4	.5	.4	5.0
14	8.4	4.2	7.1	4.6	4.5	3.8	2.1	5.6	4.4	.4	.2	5.0
15	8.3	4.8	7.0	4.6	4.4	3.7	2.3	5.7	4.3	.4	.5	4.0
16	8.1	5.8	6.9	4.5	4.2	3.6	2.6	5.7	4.2	.6	.5	3.6
17	7.9	7.1	6.8	4.5	4.2	3.5	2.7	5.7	4.1	1.1	.8	2.0
18	7.8	7.1	6.7	4.5	4.2	3.4	3.2	5.8	4.0	7.8	3.9	2.0
19	7.1	6.9	6.6	4.4	4.2	3.4	3.5	5.8	3.8	5.3	3.1	2.8
20	7.3	6.3	6.4	4.4	4.5	3.3	3.7	5.9	3.7	3.0	2.4	4.2
21	7.9	5.9	5.9	4.3	4.6	3.2	3.7	5.9	3.3	2.8	1.8	7.4
22	8.0	5.7	5.8	4.2	4.6	3.2	3.8	5.9	3.0	2.2	1.6	9.0
23	8.0	5.6	5.6	4.1	4.6	3.1	3.9	6.0	2.8	1.9	1.2	8.0
24	8.0	5.4	5.4	4.1	4.8	3.1	4.0	6.0	2.3	1.7	1.0	6.0
25	7.0	5.2	5.3	4.2	4.9	3.0	4.1	6.6	1.9	1.5	.9	6.1
26	5.2	5.2	4.9	4.2	5.0	3.0	4.1	6.5	1.7	1.3	1.2	7.0
27	5.1	5.1	4.8	4.4	5.1	2.8	4.1	5.9	1.5	1.4	1.2	6.2
28	5.1	5.1	4.9	4.6	5.1	2.7	4.2	5.8	1.2	1.4	1.2	6.6
29	4.9	....	5.1	4.8	5.2	2.6	4.2	5.7	.6	1.3	1.2	9.5
30	4.9	....	5.2	4.8	5.2	2.4	4.2	5.7	.2	1.0	1.2	11.5
31	5.0	....	5.2	....	5.2	....	4.3	....	....	1.0	....	11.2

NORTH FORK OF NEW RIVER NEAR CRUMPLER, N. C.

Location.—At J. J. Garvey's place about half a mile above the confluence of North and South forks of New River, and about 2½ miles north of Crumpler.

Drainage area.—279 square miles.

Records available.—August 13, 1908, to December 31, 1914.

Gage.—Staff attached to posts on right bank; read twice daily. Chain gage at same location used previous to July 23, 1911.

Discharge measurements.—Made from a boat or by wading.

Channel and control.—Banks high and not liable to overflow. Bed rocky; sandy near shores and clean. Control practically permanent.

Extremes of stage.—Maximum stage observed (mean of two readings): 8.2 feet, March 27, 1913. Minimum stage observed: 1.12 feet, August 19-20, 1914.

Winter flow.—Discharge relation little if at all affected by ice.

Accuracy.—Gage-height records reliable.

Data insufficient for computation of discharge.

Discharge measurements of North Fork of New River near Crumpler, N. C., in 1908–1914.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1908 Aug. 10...	O'Neill and Chapman	2.24	415	1911 July 23...	Horton and Bailey..	1.42	159
1909 June 18 ...	H. J. Jackson.....	2.88	786	1913 Dec. 17...	Walters and Peterson	1.65	212
1910 Nov. 1....	C. T. Bailey	1.64	216	1914 Oct. 11...	Mathers and Morgan	1.18	96.9

Daily gage height, in feet, of North Fork of New River near Crumpler, N. C., for 1908–1914.

[J. J. Garvey, observer.]

Day	Aug.	Sept.	Oct.	Nov.	Dec.	Day	Aug.	Sept.	Oct.	Nov.	Dec.
1908						1908					
1	....	2.10	1.70	3.22	2.90	16	2.02	1.82	1.78	2.22	2.64
2	....	2.05	1.71	2.98	2.92	17	2.10	1.82	1.76	2.25	2.58
3	....	2.00	1.62	2.75	2.62	18	2.05	1.78	1.71	2.35	2.56
4	....	1.98	1.61	2.65	2.51	19	1.95	1.78	1.68	2.55	2.71
5	....	2.02	1.60	2.47	2.55	20	1.95	1.74	1.65	2.50	2.62
6	....	2.25	1.62	2.38	2.45	21	1.92	1.72	1.65	2.46	2.54
7	....	2.70	1.60	2.36	5.30	22	2.10	1.72	1.72	2.40	2.65
8	....	2.20	1.60	2.31	4.85	23	2.10	1.71	3.88	2.30	2.51
9	....	1.92	1.86	2.22	3.30	24	2.09	1.68	6.25	2.30	2.50
10	....	1.90	3.12	2.14	3.05	25	3.50	1.66	3.59	2.24	2.52
11	....	1.90	2.10	2.25	2.90	26	3.68	1.68	2.88	2.19	3.28
12	1.93	1.87	1.95	2.43	3.45	27	2.80	1.65	2.60	2.14	2.85
13	1.89	1.86	1.80	2.22	3.10	28	2.58	1.98	2.80	2.08	2.84
14	1.87	1.82	1.80	2.29	2.90	29	2.35	2.05	4.35	2.10	3.13
15	1.83	1.80	1.78	2.30	2.70	30	2.23	1.82	4.25	2.12	3.47
						31	2.15	....	3.75	....	4.18

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	3.66	2.25	2.80	2.92	3.94	2.56	2.57	2.26	1.63	1.52	1.70	1.53
2	3.21	2.56	2.70	2.76	3.40	2.48	2.68	2.64	1.59	1.50	1.69	1.53
3	3.02	2.55	2.77	2.75	2.96	3.37	2.35	2.40	1.55	1.50	1.66	1.54
4	2.90	2.52	2.86	2.68	2.77	5.86	2.54	2.19	1.63	1.50	1.62	1.56
5	4.84	2.49	2.64	2.55	2.62	4.30	2.18	2.23	1.96	1.55	1.62	1.53
6	4.27	2.62	2.90	2.46	2.54	3.56	2.16	2.10	1.71	1.62	1.62	1.52
7	3.63	2.41	3.40	2.46	2.43	3.16	3.28	2.04	1.64	1.62	1.62	1.72
8	3.23	2.32	3.31	2.50	2.39	2.89	3.04	1.92	1.69	1.54	1.63	2.27
9	3.02	2.40	3.14	2.59	2.32	3.18	2.89	1.87	1.68	1.50	1.64	1.67
10	2.86	4.78	3.42	2.44	3.52	2.88	2.64	1.90	2.10	1.50	1.88	1.84
11	2.74	3.61	3.20	2.88	2.86	2.66	2.52	2.00	1.86	3.58	1.75	2.04
12	2.68	3.15	3.06	2.33	2.60	2.86	2.40	1.92	1.71	2.70	1.66	1.84
13	2.60	2.94	2.96	3.20	2.44	2.90	2.40	1.82	1.65	2.06	1.63	2.57
14	2.50	2.76	3.00	3.47	2.40	2.68	2.46	1.86	1.56	1.94	1.61	2.58
15	2.52	2.70	3.88	3.04	2.34	2.65	2.31	2.85	1.56	2.70	1.61	2.08
16	3.04	3.54	3.76	2.78	2.32	2.52	2.22	2.56	1.68	2.36	1.60	1.87
17	3.56	3.03	2.72	2.69	2.28	2.90	2.19	2.46	2.26	2.10	1.57	1.70
18	3.27	2.88	2.59	2.58	2.16	2.88	2.08	2.17	1.92	2.00	1.60	1.96
19	3.08	3.00	2.55	2.48	2.20	2.62	2.00	2.07	1.67	1.92	1.57	1.64
20	2.96	3.06	2.53	2.44	2.82	2.54	1.96	1.94	1.66	1.88	1.54	1.66
21	2.80	2.83	2.68	2.40	5.63	2.44	1.94	1.88	1.68	1.82	1.53	1.46
22	2.68	3.39	2.72	2.39	4.30	2.37	1.92	1.82	1.97	1.79	1.52	2.00
23	2.60	3.32	2.52	2.41	3.51	2.48	2.05	1.79	1.96	1.78	1.64	1.76
24	2.56	3.43	2.48	2.46	3.07	2.48	2.08	1.76	2.04	2.18	1.86	2.10
25	2.50	3.62	3.26	2.32	2.96	2.44	1.88	1.72	1.86	1.89	1.66	2.06
26	2.60	3.85	3.14	2.29	2.88	2.30	1.84	1.70	1.73	1.82	1.58	2.11
27	2.58	3.10	2.96	2.26	2.98	2.34	2.10	1.67	1.67	1.78	1.54	2.22
28	2.44	2.99	4.56	2.30	2.85	2.69	2.39	1.66	1.62	1.74	1.53	2.42
29	2.44	....	4.06	2.22	2.79	2.52	2.00	1.64	1.60	1.71	1.53	2.46
30	2.40	....	3.50	2.61	2.56	2.69	1.92	1.66	1.58	1.70	1.53	2.57
31	1.88	....	3.10	....	2.88	....	1.88	1.62	....	1.70	....	2.56

Daily gage height, in feet, of North Fork of New River near Crumpler, N. C., for 1908-1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
1	2.53	1.93	3.19	1.66	1.95	1.77	1.91	1.79	2.97	1.73	1.66	2.15
2	2.93	2.00	2.98	1.66	1.90	1.76	1.85	1.95	2.38	1.63	1.70	2.36
3	2.98	2.23	2.78	1.68	1.84	1.72	1.99	1.79	2.81	1.57	1.70	2.32
4	2.48	2.60	2.61	1.70	1.92	1.69	2.09	2.33	2.59	1.57	1.66	2.27
5	2.15	2.12	2.48	1.64	1.88	2.09	2.16	2.22	2.69	1.60	1.60	2.16
6	2.10	2.19	2.49	1.59	1.78	2.48	2.93	1.97	2.28	1.63	1.60	4.10
7	3.82	1.96	2.38	1.58	1.82	1.99	2.74	1.89	2.09	1.99	1.59	2.78
8	2.72	2.30	2.23	1.54	2.70	1.90	3.85	1.97	2.02	2.24	1.56	2.32
9	2.57	2.11	2.13	1.56	2.70	1.87	3.05	1.97	2.03	2.33	1.56	2.22
10	2.26	2.18	2.16	1.51	2.47	2.35	2.65	1.81	2.11	1.91	1.53	2.08
11	2.17	1.96	2.28	1.48	2.30	2.86	2.50	1.76	1.95	1.77	1.53	2.14
12	2.20	1.56	2.16	1.57	2.22	3.63	2.73	1.65	2.14	1.71	1.52	1.82
13	2.04	3.06	2.05	2.18	2.36	3.98	2.53	1.85	1.82	1.63	1.60	1.68
14	2.00	3.32	1.98	1.87	2.12	3.72	2.37	1.82	1.78	1.63	1.53	1.74
15	1.96	2.79	1.93	1.70	2.06	3.63	2.17	1.68	1.77	1.59	1.80	1.82
16	1.69	2.57	1.87	1.94	2.00	3.37	2.07	1.71	1.72	1.58	1.62	1.78
17	2.00	3.22	1.92	1.88	1.98	3.10	2.61	1.63	1.65	1.57	1.52	1.65
18	1.99	4.36	1.86	2.16	2.11	2.78	2.29	1.57	1.59	1.56	1.53	1.91
19	2.54	3.10	1.82	1.94	2.04	2.54	2.12	1.73	1.61	1.59	1.52	1.93
20	2.13	2.80	1.92	1.92	1.96	2.42	2.01	1.84	1.68	2.05	1.52	1.88
21	2.98	2.67	1.87	1.96	2.00	3.20	1.95	2.03	1.70	1.81	1.50	1.31
22	2.75	2.72	1.82	1.96	2.32	3.03	1.93	1.87	1.63	1.68	1.49	1.65
23	2.48	2.56	1.79	1.92	2.19	2.77	1.89	1.79	1.55	1.70	1.48	2.08
24	2.42	2.39	1.78	2.22	2.09	2.98	1.83	1.69	1.59	1.57	1.51	2.67
25	2.20	2.36	1.76	2.18	2.57	2.58	1.81	1.61	1.61	1.57	1.80	2.16
26	2.09	2.31	1.70	2.34	2.34	2.29	1.77	1.59	1.77	1.58	1.78	2.14
27	2.16	2.28	1.69	3.31	2.19	2.16	1.81	1.68	1.69	1.49	1.60	2.08
28	2.13	2.40	1.70	2.22	2.04	2.09	2.26	1.59	1.82	1.81	1.77	2.04
29	2.10	....	1.70	2.12	1.96	2.07	2.09	1.52	1.70	1.73	2.18	2.26
30	1.95	....	1.69	2.02	1.88	2.04	1.87	1.64	1.67	1.69	1.88	2.56
31	2.24	....	1.68	....	1.83	....	1.84	3.09	....	1.68	....	2.46
1911												
1	2.60	3.23	1.94	2.61	2.88	2.00	1.60	1.46	2.12	1.38	1.60	1.69
2	4.16	2.73	1.98	2.52	2.63	1.87	1.57	1.46	1.68	1.44	1.56	1.83
3	4.75	2.50	1.95	2.47	2.49	1.74	1.55	1.68	1.56	1.58	1.52	1.77
4	4.61	2.60	1.93	2.69	2.44	1.71	1.82	2.16	1.48	1.90	1.50	1.70
5	3.17	2.45	1.87	5.32	2.39	2.73	2.71	1.71	1.46	1.64	1.55	1.62
6	2.83	2.33	3.01	5.05	2.32	2.67	1.77	1.78	1.46	1.43	1.80	1.63
7	2.60	2.33	3.37	3.93	2.22	2.04	1.63	1.71	1.63	1.41	2.60	1.62
8	2.43	2.73	4.93	3.79	2.16	2.03	1.75	1.70	1.47	1.44	1.98	1.62
9	2.29	3.75	4.55	3.72	2.17	1.97	1.77	1.50	1.41	1.50	2.21	1.60
10	1.96	4.03	3.95	3.49	2.15	1.83	1.91	1.39	1.40	1.49	2.14	1.61
11	2.07	3.31	3.47	3.18	2.09	1.83	2.09	1.36	1.76	1.96	2.02	1.64
12	2.09	3.01	3.11	3.17	2.06	1.79	1.91	1.32	1.96	1.68	2.00	1.66
13	2.09	2.76	2.85	3.25	2.58	1.77	1.86	1.73	1.62	1.55	2.24	1.61
14	2.06	2.55	2.87	3.33	3.28	1.75	1.97	1.48	1.52	1.50	1.99	1.60
15	2.03	2.46	2.61	3.61	2.57	1.69	1.67	1.40	1.46	1.76	1.97	1.74
16	1.97	4.33	2.46	3.56	2.35	1.64	1.61	1.49	1.49	1.64	1.88	2.16
17	1.89	2.25	2.39	3.23	2.23	1.65	1.57	1.43	1.48	3.41	1.82	2.12
18	1.95	2.21	2.37	2.95	2.17	1.67	1.56	1.38	1.54	3.71	1.91	1.84
19	1.93	2.19	2.40	3.89	2.18	1.69	1.51	1.43	1.45	2.55	2.06	1.76
20	1.91	2.29	2.59	3.43	2.09	2.02	1.51	1.40	1.43	2.14	1.96	1.71
21	2.05	2.20	2.28	3.03	2.07	1.77	1.55	1.35	2.02	1.98	1.95	2.00
22	2.19	2.03	2.21	2.95	1.99	1.67	1.55	1.30	2.00	2.02	1.87	2.43
23	3.01	2.18	2.34	2.73	1.99	1.61	1.46	1.27	1.68	2.20	1.84	3.29
24	2.65	2.09	2.21	2.59	2.11	1.75	1.40	1.28	1.52	1.86	1.94	2.78
25	2.46	2.01	2.19	2.49	1.95	1.68	1.52	1.28	1.50	1.78	1.92	2.88

Daily gage height, in feet, of North Fork of New River near Crumpler, N. C., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
26	2.45	1.99	2.21	2.45	1.91	1.64	1.46	1.34	1.50	1.73	1.86	2.73
27	2.46	2.01	3.17	2.37	1.85	2.29	1.38	1.56	1.48	1.70	1.88	3.00
28	2.59	1.96	2.71	2.31	1.83	2.31	1.36	1.47	1.44	1.68	1.92	2.70
29	2.65	....	2.65	2.35	1.79	1.94	1.35	1.66	1.46	1.66	1.92	2.51
30	4.05	....	2.78	2.43	1.74	1.69	1.33	1.95	1.45	1.63	1.75	2.39
31	3.70	....	2.66	....	1.87	....	1.36	3.09	....	1.60	....	2.64
1912												
1	2.55	2.9	2.5	3.0	2.65	1.92	1.86	2.1	1.64	1.66	1.47	1.66
2	2.4	2.6	2.35	4.3	2.5	2.5	2.05	1.78	1.56	1.62	1.53	1.58
3	2.35	2.45	2.4	4.1	2.45	2.5	2.45	1.70	1.56	1.59	1.47	1.72
4	2.25	2.1	2.3	3.4	2.35	2.0	2.55	2.1	1.54	1.60	1.42	1.61
5	2.05	1.97	2.45	3.1	2.4	1.97	3.2	1.94	1.56	1.56	1.46	1.78
6	1.84	2.1	2.4	2.85	2.4	1.90	3.5	1.76	1.52	1.55	1.44	1.82
7	2.75	2.05	2.55	2.75	2.55	2.05	2.7	1.71	1.52	1.52	2.15	1.75
8	2.65	2.15	2.9	2.7	2.45	1.90	2.35	1.68	2.35	1.50	2.30	1.64
9	2.65	2.0	2.4	2.5	2.4	1.78	2.25	1.76	1.67	1.48	1.83	1.60
10	2.6	2.0	3.2	2.4	2.25	1.72	2.15	2.05	1.52	1.47	1.70	1.53
11	2.65	1.86	2.85	2.35	2.2	1.70	2.1	1.82	1.46	1.46	1.65	1.56
12	2.6	1.92	2.8	2.3	2.5	1.68	2.25	1.74	1.44	1.46	1.60	1.52
13	2.6	1.90	3.3	2.25	2.3	1.66	1.99	1.70	1.54	1.46	1.60	1.33
14	2.3	1.88	3.2	2.2	2.15	1.77	1.98	1.69	1.54	1.66	1.78	1.62
15	2.35	1.86	5.1	2.2	2.3	2.0	2.05	1.65	1.54	1.87	1.67	1.54
16	2.4	1.86	5.0	2.2	3.2	2.2	1.84	1.62	1.51	1.58	1.58	1.63
17	2.25	1.94	3.8	2.25	2.85	1.80	1.86	1.60	1.47	1.52	1.54	1.43
18	2.5	2.05	3.3	2.2	2.6	1.78	1.84	1.66	1.59	1.48	1.52	1.58
19	2.95	2.3	3.0	2.1	2.45	1.82	2.15	1.69	2.3	1.58	1.50	1.56
20	3.4	2.4	2.85	2.05	2.3	1.75	2.1	3.3	1.90	1.74	1.50	1.42
21	2.8	3.1	2.75	2.15	2.2	1.67	2.15	2.65	1.52	1.57	1.49	1.46
22	2.45	3.6	2.65	2.35	2.15	1.62	1.90	2.3	1.48	1.56	1.49	1.47
23	2.4	2.8	2.55	2.55	2.1	1.74	1.88	2.1	3.6	1.61	1.49	1.50
24	2.3	2.75	3.2	2.25	2.0	2.0	1.78	1.89	3.2	1.65	1.48	1.50
25	2.3	2.85	3.2	2.2	2.0	2.85	2.25	1.82	2.15	1.54	1.48	1.64
26	2.2	2.95	3.1	2.1	2.0	2.0	2.0	1.78	1.96	1.51	1.46	1.78
27	2.3	3.7	2.95	2.45	1.9	1.85	1.82	1.77	2.05	1.48	1.48	1.98
28	2.05	3.2	2.8	2.6	1.88	1.88	1.76	1.68	1.89	1.48	1.62	2.0
29	2.7	2.75	4.6	2.55	2.35	1.91	1.70	1.62	1.76	1.48	1.96	1.98
30	3.7	....	3.8	2.95	2.2	2.05	2.2	1.63	1.73	1.46	1.70	2.15
31	3.2	....	3.3	....	1.98	....	1.84	1.87	....	1.44	....	2.85
1913												
1	2.25	2.45	2.9	2.7	2.0	2.5	1.78	1.41	1.57	1.74	1.69	2.0
2	1.88	2.1	2.55	2.55	1.97	2.4	1.84	2.05	1.56	1.64	1.64	2.3
3	2.0	2.25	2.3	2.45	1.89	2.3	2.95	1.58	1.55	1.62	1.63	1.93
4	2.05	2.5	2.2	2.35	1.92	2.3	2.6	1.44	1.84	1.59	1.62	1.83
5	2.25	2.5	2.2	2.3	1.88	2.2	2.25	1.39	2.85	1.56	1.60	1.80
6	2.45	2.3	2.05	2.2	1.87	2.1	1.88	2.25	2.0	1.54	1.60	1.74
7	2.45	2.0	1.86	2.15	1.92	2.05	1.74	1.54	1.78	1.52	1.58	1.87
8	2.3	2.05	2.05	2.15	2.05	2.35	1.66	2.05	1.66	1.52	1.62	2.0
9	2.3	2.1	1.91	2.3	1.95	2.2	1.64	1.66	1.66	1.61	2.25	1.72
10	2.1	2.15	2.1	2.15	1.87	2.1	1.61	1.68	1.63	1.68	1.88	1.74
11	2.05	2.05	2.35	2.5	1.81	1.97	1.63	1.54	1.55	1.60	1.78	2.05
12	2.1	2.2	2.2	3.2	1.79	2.1	1.80	1.45	1.51	1.56	1.74	1.78
13	2.4	1.80	2.2	5.0	1.75	2.1	1.70	1.95	1.49	1.56	1.86	1.86
14	2.2	1.86	5.7	3.5	1.78	1.91	1.62	2.05	1.47	1.50	1.85	1.85
15	2.1	1.82	5.6	3.4	1.78	1.83	1.60	1.83	1.50	1.48	1.83	1.75
16	2.0	1.79	4.6	3.2	2.2	1.81	1.56	1.57	1.75	1.48	1.80	1.69
17	1.95	1.82	3.5	3.0	2.1	1.78	1.52	1.48	1.94	1.48	2.4	1.68
18	1.95	1.78	3.0	2.8	2.1	1.74	1.50	1.50	1.81	1.50	2.15	1.68
19	2.0	1.74	2.75	2.6	1.86	2.35	1.46	1.89	2.25	1.56	2.0	1.66
20	1.86	1.91	2.6	2.55	1.90	1.87	1.60	3.1	1.86	2.05	1.92	1.62

Daily gage height, in feet, of North Fork of New River near Crumpler, N. C., for 1908-1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
21	1.82	2.4	2.7	2.4	2.65	1.78	1.52	1.93	3.45	1.86	1.84	1.60
22	1.96	2.2	2.75	2.3	2.5	1.72	1.46	1.78	2.65	1.70	1.80	1.60
23	1.86	2.1	2.4	2.25	4.0	1.84	1.42	2.5	2.2	1.74	1.76	1.62
24	1.92	1.99	2.35	2.2	4.9	1.92	1.40	2.05	1.97	2.2	1.73	1.68
25	2.35	1.94	2.6	2.15	3.4	1.72	1.40	1.80	1.86	2.75	1.66	1.72
26	2.35	1.90	2.55	2.1	2.85	2.7	1.48	1.66	1.78	2.15	1.64	2.4
27	2.9	2.5	8.2	2.3	4.0	1.84	1.48	1.58	1.72	1.98	1.64	1.80
28	3.5	3.4	5.5	2.1	4.2	1.76	1.75	1.55	1.68	1.89	1.63	1.98
29	2.9	....	3.75	2.1	3.45	1.68	1.97	1.47	1.69	1.82	1.63	1.86
30	2.55	....	3.3	2.15	3.0	1.76	1.64	2.55	2.0	1.76	1.64	1.98
31	2.4	....	3.0	....	2.7	....	1.48	1.72	....	1.70	....	1.95
1914												
1	1.94	3.0	2.4	3.8	2.1	1.64	1.18	1.22	1.38	1.18	1.41	4.3
2	1.89	2.6	2.4	3.7	2.05	1.60	1.20	1.20	1.34	1.18	1.40	4.8
3	2.0	2.4	2.4	3.3	2.05	1.59	1.92	1.17	1.30	1.18	1.40	3.9
4	1.90	2.3	2.45	3.0	2.05	1.56	1.52	1.48	1.29	1.32	1.40	4.9
5	1.92	2.25	2.3	2.75	2.3	1.60	1.58	1.34	1.26	1.50	1.38	5.9
6	1.89	3.1	2.25	2.6	3.1	2.25	1.46	1.26	1.22	1.34	1.36	4.2
7	1.83	3.6	2.25	2.5	2.7	1.88	1.38	1.20	1.20	1.28	1.34	3.4
8	1.83	3.1	2.2	2.5	2.5	1.81	1.38	1.18	1.20	1.25	1.34	3.1
9	2.3	2.7	2.15	2.4	2.5	1.67	1.33	1.20	1.40	1.28	1.50	2.75
10	3.2	2.55	2.15	2.2	2.4	1.82	1.85	1.31	1.32	1.21	1.52	2.6
11	2.6	2.45	2.5	2.2	2.25	1.64	1.50	1.36	1.30	1.20	1.41	2.45
12	2.2	2.3	4.2	2.15	2.2	1.52	1.46	1.30	1.78	1.18	1.37	2.35
13	1.92	2.3	3.3	2.1	2.1	1.60	1.30	1.24	1.46	1.20	1.36	2.55
14	2.0	2.1	2.9	2.25	2.15	1.56	2.15	1.40	1.32	1.40	1.38	2.35
15	2.3	2.2	2.75	3.9	2.05	1.61	2.35	1.40	1.26	2.15	2.75	2.0
16	2.05	2.2	2.75	3.5	2.0	1.51	2.0	1.34	1.18	3.9	2.5	1.82
17	2.15	1.81	2.9	3.4	1.98	1.43	1.71	1.22	1.26	2.2	2.15	2.05
18	1.84	2.6	3.2	3.1	1.97	1.42	2.0	1.18	1.74	2.05	1.88	2.1
19	1.98	3.0	3.8	2.8	1.92	1.57	1.64	1.13	1.52	1.94	1.86	2.25
20	1.93	4.4	2.8	3.2	1.88	1.52	1.48	1.12	1.55	1.80	1.80	3.0
21	2.25	3.8	2.55	2.9	1.85	1.50	1.40	1.24	1.42	1.68	1.46	2.95
22	2.05	3.1	2.55	2.7	1.82	1.48	1.37	1.33	1.32	1.62	1.94	3.1
23	1.96	2.9	2.4	2.6	1.80	1.41	1.34	1.26	1.26	1.56	1.74	2.65
24	2.1	3.1	2.4	2.5	1.79	1.40	1.29	1.15	1.22	1.72	1.54	2.5
25	2.85	2.8	2.35	2.45	1.77	1.38	1.24	1.14	1.28	1.72	1.60	4.6
26	2.4	2.7	2.4	2.5	1.72	1.42	1.22	1.48	1.32	1.59	1.70	4.2
27	2.25	2.55	2.5	2.4	1.70	1.36	1.42	2.05	1.24	1.53	1.63	3.2
28	2.15	2.45	2.6	2.25	1.69	1.32	1.38	3.5	1.20	1.50	1.60	2.9
29	2.1	....	2.7	2.2	1.68	1.23	1.48	2.05	1.18	1.48	1.58	2.9
30	2.05	....	3.9	2.2	1.82	1.18	1.38	1.66	1.18	1.46	3.6	3.4
31	3.3	....	4.0	....	1.67	....	1.27	1.48	....	1.42	....	3.0

NOTE.—Ice present in stream as follows:

1909: Dec. 10-31, ice 0.75 foot thick Dec. 31.
1910: Jan. 1-11, and during December.
1911: Slush ice reported Feb. 23.
1912: Jan. 6-29, ice from 3 to 12 inches thick; Feb. 3-17, ice about 4 inches thick.
1913: Feb. 8-17; slush ice Feb. 9.
1914: Jan. 12-16 and Feb. 15-17.

REED CREEK AT GRAHAMS FORGE, VA.

Location.—At highway bridge at Grahams Forge.

Drainage area.—247 square miles.

Records available.—July 29, 1908, to December 31, 1914.

Gage.—Chain attached to bridge; read twice daily.

Discharge measurements.—Made from the bridge.

Channel and control.—Left bank will overflow at high stages; right bank high and rocky. Bed of stream rocky, clean, and permanent.

Extremes of stage.—Maximum mean daily gage height: 7.9 feet, March 27, 1913. Minimum stage observed: 1.17 feet at 7.30 A. M., December 22, 1909.

Winter flow.—Discharge relation probably affected by ice for short periods.

Regulation.—There is a dam and grist mill about 400 feet above the station. The storage is small and it is stated that water flows over the dam at all times.

Accuracy.—Gage-height record reliable.

Data insufficient for computation of discharge.

Discharge measurements of Reed Creek at Grahams Forge, Va., in 1908–1914.

Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*
1908			
July 30	O'Neill and Chapman	2.46	243
Aug. 15	W. M. O'Neill	2.29	158
1909			
June 16	H. J. Jackson	2.80	383
Dec. 9	A. H. Horton	2.34	152
1910			
Mar. 18	C. T. Bailey	2.41	192
Oct. 21	do	2.09	95.1
1911			
July 20	Horton and Bailey	2.16	106
1912			
Sept. 24	C. T. Bailey	3.80	1,330
1913			
Dec. 13	Peterson and Walters	2.13	99
1914			
Oct. 8	Mathers and Morgan	2.10	67.0
Oct. 8	do	2.08	59.7

Daily gage height, in feet, of Reed Creek at Grahams Forge, Va., for 1908–1914.

[Robert Runion, Munsey Runion, and J. T. Black, observers.]

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908							1908						
1	......	2.38	2.33	2.24	2.97	2.58	16	......	2.25	2.24	2.28	2.49	2.77
2	......	2.31	2.32	2.20	2.90	2.88	17	......	2.37	2.24	2.27	2.51	2.69
3	......	2.27	2.26	2.18	2.76	2.78	18	......	2.32	2.22	2.22	2.67	2.67
4	......	2.26	2.22	2.19	2.70	2.70	19	......	2.27	2.22	2.26	3.19	2.67
5	......	2.24	2.32	2.14	2.62	2.64	20	......	2.25	2.24	2.20	3.08	2.65
6	......	2.24	2.38	2.18	2.56	2.60	21	......	2.24	2.20	2.28	2.82	2.60
7	......	2.23	2.40	2.17	2.53	3.18	22	......	2.26	2.19	2.28	2.74	2.65
8	......	2.24	3.18	2.18	2.50	3.58	23	......	2.22	2.20	2.21	2.64	2.65
9	......	2.48	2.48	2.22	2.48	3.14	24	......	2.26	2.20	3.17	2.61	2.65
10	......	2.50	2.42	2.46	2.48	2.88	25	......	2.42	2.15	2.72	2.58	2.72
11	......	2.47	2.36	2.82	2.52	2.78	26	......	2.68	2.20	2.52	2.54	3.91
12	......	2.38	2.30	2.50	2.51	2.96	27	......	2.54	2.20	2.48	2.48	3.27
13	......	2.30	2.20	2.41	2.48	3.24	28	......	2.48	2.20	2.58	2.48	3.17
14	......	2.24	2.28	2.33	2.50	3.02	29	......	2.41	2.31	3.92	2.48	3.39
15	......	2.25	2.23	2.32	2.51	2.86	30	2.48	2.39	2.25	4.58	2.48	3.72
							31	2.42	2.32	......	3.48	......	4.09

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	3.62	2.59	2.80	2.90	4.46	2.45	2.66	2.28	2.19	2.17	2.18	2.10
2	3.27	2.61	2.76	2.82	3.57	2.52	2.68	2.68	2.13	2.20	2.19	2.06
3	3.31	2.66	2.76	2.76	3.19	2.61	2.62	2.54	2.16	2.11	2.19	2.08
4	3.47	2.57	2.86	2.71	2.95	3.28	2.72	2.42	2.15	2.14	2.20	2.11
5	4.59	2.56	2.78	2.68	2.83	3.16	2.68	2.41	2.18	2.19	2.20	2.15
6	4.09	3.55	2.78	2.65	2.77	2.85	2.49	2.38	2.16	2.17	2.20	2.09
7	3.43	2.57	3.26	2.60	2.63	2.74	2.70	2.28	2.18	2.14	2.21	2.20
8	3.22	2.57	3.40	2.59	2.55	2.63	2.96	2.28	2.19	2.14	2.12	2.40
9	3.09	2.61	3.28	2.58	2.57	3.10	2.76	2.26	2.31	2.18	2.20	2.35
10	2.99	3.28	3.27	2.54	3.33	2.89	2.62	2.21	2.38	2.15	2.21	2.00
11	2.93	3.35	3.22	2.50	3.27	2.74	2.53	2.22	2.25	2.82	2.23	2.20
12	2.87	3.08	3.04	2.52	3.00	2.67	2.48	2.24	2.20	3.10	2.14	2.26
13	2.81	2.85	2.98	2.76	2.85	3.74	2.45	2.23	2.16	2.56	2.20	2.40
14	2.76	2.79	3.01	3.38	2.73	3.17	2.50	2.28	2.19	2.48	2.24	2.58
15	2.77	2.72	2.90	2.94	2.65	2.91	2.39	2.34	2.20	2.54	2.11	2.42
16	3.17	2.84	2.84	2.85	2.59	2.82	2.36	2.59	3.02	2.59	2.12	2.35
17	3.92	2.90	2.77	2.79	2.56	3.02	2.32	2.64	2.61	2.46	2.20	2.34
18	3.67	2.78	2.72	2.66	2.54	2.86	2.32	2.52	2.66	2.40	2.18	2.28
19	3.40	2.78	2.66	2.65	2.51	2.72	2.32	2.37	2.49	2.44	2.17	2.26
20	3.29	2.86	2.06	2.64	2.57	2.63	2.30	2.30	2.36	2.36	2.16	2.19
21	3.15	2.84	2.76	2.67	3.53	2.60	2.28	2.26	2.36	2.31	2.19	2.15
22	3.05	2.94	3.21	2.67	3.70	2.67	2.26	2.25	2.30	2.32	1.90	1.71
23	2.97	3.34	3.00	2.69	3.13	2.58	2.26	2.16	2.26	2.36	2.11	1.70
24	2.91	3.16	2.88	2.67	2.91	2.53	2.25	2.15	2.55	2.34	2.15	2.16
25	2.87	3.16	3.36	2.64	2.84	2.55	2.21	2.20	2.40	2.32	2.15	2.14
26	2.85	3.10	3.37	2.62	2.85	2.55	2.24	2.20	2.32	2.28	2.00	2.17
27	2.82	2.98	3.10	2.57	2.85	2.60	2.25	2.18	2.26	2.26	2.12	2.16
28	2.77	2.88	3.91	2.54	2.74	2.58	2.29	2.16	2.20	2.25	2.11	2.17
29	2.75	....	3.68	2.52	2.65	2.72	2.34	2.19	2.20	2.20	2.06	2.18
30	2.70	....	3.16	3.51	2.59	2.66	2.25	2.16	2.16	2.20	2.06	2.14
31	2.57	....	3.04	....	2.52	....	2.28	2.18	....	2.25	....	2.15
1910												
1	2.16	2.42	2.62	2.24	2.54	2.23	2.30	2.22	2.08	2.08	2.04	2.08
2	2.15	2.40	2.88	2.24	2.48	2.22	2.34	2.25	2.17	2.07	2.00	2.05
3	2.50	2.42	2.84	2.24	2.42	2.20	2.36	2.26	2.20	2.06	2.02	2.06
4	2.52	2.48	2.78	2.38	2.41	2.21	2.36	2.42	2.14	2.08	2.02	2.07
5	2.40	2.46	2.73	2.34	2.36	2.28	2.38	2.39	2.10	2.06	2.08	2.06

Daily gage height, in feet, of Reed Creek at Grahams Forge, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
6	2.40	2.58	2.75	2.32	2.34	2.68	2.49	2.31	2.14	2.06	2.04	2.52
7	3.20	2.52	2.91	2.31	2.33	2.56	2.56	2.26	2.14	2.08	2.02	2.48
8	3.00	2.46	2.76	2.20	2.40	2.42	2.51	2.23	2.15	2.19	2.00	2.25
9	2.62	2.44	2.66	2.22	2.44	2.36	2.47	2.28	2.16	2.21	2.00	2.19
10	2.50	2.40	2.60	2.16	2.40	2.40	2.46	2.26	2.22	2.09	2.04	2.10
11	2.53	2.36	2.60	2.31	2.38	3.44	2.38	2.27	2.24	2.09	2.04	2.16
12	2.46	2.31	2.55	2.31	2.34	3.44	2.36	2.21	2.18	2.07	2.04	2.12
13	2.40	2.32	2.46	3.22	2.32	4.80	2.38	2.20	2.14	2.08	2.02	2.08
14	2.36	2.38	2.41	2.90	2.81	4.40	2.35	2.20	2.16	2.08	2.04	2.14
15	2.34	2.48	2.41	2.64	2.32	3.74	2.33	2.14	2.14	2.05	2.06	2.10
16	2.31	2.64	2.35	2.58	2.35	3.32	2.30	2.17	2.10	2.01	2.04	2.12
17	2.28	3.11	2.39	2.65	2.35	3.40	2.42	2.04	2.10	2.02	2.04	2.10
18	2.30	4.25	2.34	2.80	2.35	3.16	2.64	2.08	2.10	2.01	2.06	2.08
19	2.32	3.14	2.33	2.76	2.46	2.84	2.55	2.18	2.04	2.05	2.04	2.05
20	2.45	2.91	2.30	2.64	2.49	2.95	2.47	2.14	2.10	2.11	2.03	2.00
21	2.58	2.86	2.51	2.64	2.51	2.78	2.34	2.09	2.08	2.48	2.00	2.00
22	2.55	2.80	2.48	2.69	2.49	2.69	2.34	2.16	2.10	2.10	2.02	2.06
23	2.88	2.72	2.32	2.67	2.54	2.63	2.26	2.02	2.11	2.10	2.02	2.14
24	2.74	2.60	2.29	2.66	2.47	2.60	2.29	2.09	2.11	2.05	2.08	2.11
25	2.59	2.56	2.31	2.75	2.64	2.58	2.28	2.10	2.07	2.07	2.08	2.17
26	2.51	2.50	2.28	2.84	2.74	2.54	2.81	2.02	2.05	2.04	2.05	2.20
27	2.47	2.50	2.28	2.86	2.54	2.46	2.28	2.10	2.12	2.06	2.04	2.17
28	2.48	2.50	2.28	2.74	2.48	2.41	2.28	2.15	2.32	2.07	2.04	2.21
29	2.47	....	2.30	2.64	2.38	2.40	2.26	2.08	2.06	2.06	2.10	2.19
30	2.44	....	2.26	2.54	2.28	2.34	2.20	2.10	2.06	2.02	2.13	2.28
31	2.48	....	2.26	....	2.25	....	2.26	2.09	....	2.02	....	2.38
1911												
1	2.42	3.20	2.43	2.72	2.65	2.32	2.12	2.04	2.65	2.00	2.30	2.19
2	3.38	3.97	2.42	2.72	2.60	2.26	2.18	2.04	2.31	2.23	2.23	2.16
3	3.71	2.84	2.40	2.74	2.55	2.24	2.08	2.00	2.26	2.96	2.25	2.20
4	3.42	2.74	2.40	3.60	2.52	2.21	2.09	2.08	2.16	2.48	2.18	2.22
5	2.88	2.72	2.38	4.14	2.51	2.20	2.08	2.36	2.12	2.28	2.18	2.18
6	2.62	2.64	2.39	4.08	2.48	2.24	2.15	2.20	2.18	2.16	2.35	2.10
7	2.52	2.58	3.26	3.64	2.46	2.20	2.12	2.16	2.16	2.14	2.64	2.25
8	2.48	2.60	3.20	3.46	2.44	2.28	2.14	2.20	2.14	2.14	2.50	2.14
9	2.41	3.88	3.31	3.57	2.44	2.20	2.18	2.20	2.16	2.12	2.57	2.12
10	2.30	4.20	3.82	3.50	2.42	2.21	2.18	2.16	2.12	2.19	2.71	2.10
11	2.30	3.40	3.55	3.30	2.44	2.18	2.16	2.08	2.18	2.26	2.60	2.24
12	2.30	3.32	3.18	3.08	2.39	2.16	2.42	2.02	2.16	2.28	2.56	2.11
13	2.30	2.94	3.02	3.02	2.38	2.18	2.24	2.52	2.16	2.24	2.52	2.20
14	2.30	2.84	2.86	3.04	2.59	2.18	2.22	2.32	2.13	2.22	2.50	2.17
15	2.28	2.76	2.84	3.37	2.50	2.15	2.17	2.22	2.06	2.14	2.45	2.28
16	2.28	2.69	2.80	3.55	2.46	2.16	2.14	2.16	2.00	2.14	2.40	2.22
17	2.26	2.61	2.72	3.24	2.43	2.16	2.14	2.18	2.14	2.32	2.38	2.32
18	2.26	2.57	2.68	3.07	2.42	2.18	2.10	2.20	2.03	4.66	2.39	2.32
19	2.26	2.59	2.68	2.98	2.38	2.19	2.10	2.12	1.99	3.10	2.40	2.30
20	2.12	2.66	2.72	3.14	2.34	2.32	2.11	2.10	2.14	2.76	2.40	2.31
21	2.26	2.70	2.70	3.20	2.32	2.28	1.88	2.06	2.04	2.60	2.37	2.33
22	2.62	2.65	2.66	3.06	2.31	2.18	2.04	2.05	2.26	2.52	2.36	2.38
23	3.54	2.66	2.64	2.94	2.28	2.20	2.04	2.00	2.28	2.50	2.34	3.56
24	3.24	2.58	2.58	2.83	2.28	2.16	2.02	2.05	2.16	2.46	2.34	3.05
25	2.80	2.54	2.55	2.76	2.26	2.14	2.02	2.14	2.12	2.43	2.33	3.10
26	2.68	2.50	2.50	2.72	2.26	2.16	2.03	2.20	2.12	2.38	2.29	2.99
27	2.60	2.48	2.76	2.66	2.26	2.16	2.02	2.42	2.04	2.36	2.29	3.00
28	2.59	2.46	2.86	2.62	2.24	2.18	2.03	2.24	2.03	2.30	2.26	2.92
29	2.67	....	2.77	2.60	2.20	2.16	2.02	2.18	2.04	2.32	2.31	2.72
30	4.52	....	2.77	2.61	2.23	2.16	2.05	2.30	1.99	2.29	2.22	2.68
31	3.62	....	2.74	....	2.22	....	2.00	2.60	....	2.30	....	2.70

Daily gage height, in feet, of Reed Creek at Grahams Forge, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	2.71	2.92	2.90	3.3	2.94	2.44	2.72	2.80	2.18	2.31	2.16	2.12
2	2.67	2.78	2.80	4.1	2.81	2.42	2.89	2.59	2.15	2.27	2.15	2.14
3	2.61	2.55	2.79	4.5	2.74	2.46	2.69	2.46	2.15	2.28	2.14	2.17
4	2.60	2.52	2.72	3.65	2.68	2.43	2.59	2.48	2.13	2.26	2.14	2.20
5	2.32	2.68	2.70	3.3	2.60	2.44	2.92	2.44	2.16	2.21	2.08	2.36
6	2.50	2.70	2.74	3.2	2.67	2.38	2.96	2.38	2.16	2.22	2.15	2.40
7	2.50	2.60	2.80	3.1	2.78	2.40	2.72	2.32	2.14	2.21	2.27	2.38
8	2.50	2.50	3.20	3.05	2.83	2.36	2.66	2.30	2.22	2.20	2.69	2.37
9	2.44	2.42	3.9	2.92	2.80	2.29	2.56	2.30	2.19	2.19	2.45	2.31
10	2.62	2.42	3.6	2.86	2.70	2.30	2.50	2.37	2.12	2.17	2.34	2.26
11	2.44	2.44	3.25	2.82	2.72	2.28	2.56	2.34	2.14	2.18	2.29	2.24
12	2.40	2.40	3.15	2.84	2.91	2.27	2.61	2.28	2.13	2.16	2.28	2.22
13	2.44	2.38	4.3	2.74	3.45	2.25	2.60	2.26	2.14	2.17	2.24	2.14
14	2.52	2.37	4.2	2.72	3.05	2.28	2.46	2.23	2.14	2.26	2.22	2.22
15	2.32	2.42	5.2	2.68	2.94	2.25	2.40	2.23	2.14	2.32	2.22	2.16
16	2.42	2.40	4.8	2.78	4.2	2.30	2.34	2.22	2.12	2.28	2.20	2.18
17	2.20	2.36	3.8	2.73	3.9	2.32	2.30	2.20	2.14	2.20	2.17	2.18
18	2.34	2.40	3.45	2.79	3.3	2.28	2.28	2.27	2.36	2.17	2.18	2.20
19	2.48	2.52	3.25	2.74	3.05	2.26	2.44	2.27	2.86	2.20	2.18	2.19
20	3.05	2.63	3.15	2.70	2.90	2.25	2.30	2.27	2.37	2.24	2.18	2.14
21	2.92	3.3	3.0	2.66	2.79	2.21	2.26	2.30	2.26	2.22	2.16	2.08
22	2.74	3.9	2.97	2.71	2.72	2.24	2.32	2.26	2.20	2.20	2.16	2.09
23	2.64	3.15	2.88	2.91	2.66	2.23	2.30	2.32	3.15	2.20	2.14	2.12
24	2.62	2.98	3.05	2.83	2.62	2.38	2.26	2.36	3.7	2.18	2.17	2.14
25	2.52	3.25	3.55	2.74	2.60	3.4	2.32	2.28	2.90	2.16	2.15	2.16
26	2.50	3.4	3.3	2.67	2.55	2.76	2.44	2.27	2.64	2.20	2.12	2.12
27	2.60	3.9	3.1	2.87	2.53	2.70	2.31	2.28	2.52	2.16	2.08	2.21
28	2.61	3.35	2.99	3.4	2.56	3.2	2.24	2.24	2.47	2.14	2.15	2.18
29	2.65	3.1	5.7	3.05	2.51	2.71	2.28	2.20	2.38	2.16	2.09	2.20
30	2.70	....	4.1	3.1	2.52	2.79	2.64	2.21	2.35	2.15	2.14	2.36
31	3.2	....	3.5	....	2.48	....	2.58	2.20	....	2.16	....	3.25
1913												
1	2.76	2.81	3.15	3.05	2.51	2.82	2.29	2.17	2.18	2.14	2.10	2.33
2	2.58	2.70	2.91	2.96	2.48	2.74	2.30	2.16	2.15	2.16	2.10	2.56
3	2.60	2.70	2.75	2.88	2.46	2.68	2.82	2.16	2.14	2.14	2.11	2.46
4	2.68	2.81	2.66	2.81	2.44	2.62	2.40	2.14	2.24	2.10	2.14	2.34
5	2.62	2.85	2.60	2.76	2.44	2.60	2.64	2.14	2.16	2.12	2.13	2.29
6	2.62	2.76	2.53	2.70	2.42	2.56	2.36	3.5	2.19	2.10	2.12	2.24
7	2.64	2.68	2.50	2.66	2.44	2.52	2.30	2.44	2.12	2.13	2.11	2.29
8	2.62	2.62	2.48	2.66	2.40	2.55	2.23	2.30	2.12	2.14	2.06	2.32
9	2.56	2.56	2.44	2.64	2.40	2.56	2.24	2.24	2.13	2.14	2.26	2.32
10	2.50	2.56	2.46	2.60	2.39	2.51	2.21	2.24	2.13	2.12	2.42	2.27
11	2.42	2.52	2.58	2.60	2.36	2.42	2.27	2.19	2.14	2.12	2.22	2.28
12	2.46	2.54	2.60	2.90	2.32	2.52	2.34	2.39	2.13	2.12	2.19	2.24
13	2.82	2.49	2.55	4.7	2.42	2.54	2.32	2.46	2.09	2.10	2.16	2.21
14	2.68	2.48	4.45	3.7	2.32	2.43	2.22	2.31	2.09	2.10	2.16	2.20
15	2.56	2.48	4.6	3.45	2.04	2.38	2.22	2.45	2.10	2.10	2.17	2.11
16	2.50	2.48	4.15	3.4	2.42	2.40	2.20	2.26	2.13	2.15	2.18	2.08
17	2.48	2.44	3.4	3.25	2.38	2.37	2.20	2.22	2.16	2.12	2.20	2.14
18	2.45	2.42	3.1	3.1	2.38	2.34	2.21	2.18	2.15	2.10	2.32	2.10
19	2.40	2.38	2.96	2.96	2.32	2.52	2.17	3.05	2.21	2.14	2.24	2.08
20	2.41	2.40	2.89	2.86	2.31	2.46	2.21	2.66	2.16	2.28	2.22	2.12
21	2.36	2.44	2.82	2.78	2.51	2.38	2.20	2.45	2.34	2.24	2.18	2.10
22	2.38	2.46	2.78	2.72	2.74	2.36	2.19	2.37	2.39	2.18	2.17	2.10
23	2.40	2.44	2.65	2.70	4.15	2.50	2.20	2.44	2.24	2.14	2.16	2.06
24	2.41	2.46	2.64	2.64	4.4	2.88	2.32	2.34	2.18	2.17	2.14	2.12
25	2.48	2.44	2.62	2.62	3.35	2.58	2.15	2.30	2.13	2.28	2.06	2.15

Daily gage height, in feet, of Reed Creek at Grahams Forge, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
26	2.66	2.40	2.79	2.60	3.0	2.46	2.00	2.26	2.12	2.21	2.12	2.32
27	3.25	2.70	7.9	2.63	3.85	2.42	2.16	2.22	2.12	2.20	2.10	2.31
28	3.9	3.6	4.6	2.60	4.25	2.37	2.26	2.18	2.10	2.16	2.12	2.24
29	3.25	....	3.7	2.59	3.45	2.34	2.56	2.18	2.12	2.14	2.02	2.31
30	2.97	....	3.45	2.54	3.15	2.30	2.30	2.25	2.21	2.11	2.08	2.30
31	2.84	....	3.25	....	2.98	....	2.22	2.26	....	2.14	....	2.38
1914												
1	2.46	2.94	2.92	3.6	2.44	2.18	2.06	2.05	2.16	2.11	2.08	2.82
2	2.40	2.74	2.75	3.6	2.43	2.18	2.12	2.12	2.13	2.08	2.12	3.1
3	2.38	2.66	2.78	3.35	2.40	2.18	2.14	2.04	2.12	2.10	2.16	3.35
4	2.44	2.57	2.77	3.1	2.42	2.19	2.10	2.12	2.14	2.10	2.18	3.35
5	2.44	2.56	2.74	2.94	2.48	2.18	2.07	1.92	2.08	2.04	2.17	4.9
6	2.39	2.88	2.73	2.85	2.64	2.18	2.08	2.04	2.12	2.15	2.16	3.6
7	2.40	3.9	2.73	2.78	2.64	2.20	2.12	2.08	2.02	2.14	2.14	3.15
8	2.43	3.45	2.73	2.76	2.62	2.19	2.09	2.10	2.14	2.12	2.16	2.92
9	2.63	3.05	2.70	2.72	2.58	2.30	2.14	2.10	2.15	2.10	2.06	2.79
10	3.45	2.86	2.66	2.64	2.54	2.08	2.18	2.08	2.24	2.10	2.16	2.70
11	3.1	2.76	3.1	2.60	2.48	2.08	2.34	2.12	2.10	2.08	2.16	2.60
12	2.82	2.66	4.2	2.59	2.46	2.16	2.16	2.13	1.91	2.00	2.16	2.52
13	2.64	2.63	3.45	2.56	2.43	2.13	2.09	2.13	2.17	2.12	2.16	2.50
14	2.64	2.54	3.2	2.56	2.40	2.16	2.36	2.12	2.05	2.11	2.14	2.48
15	2.54	2.60	3.1	2.80	2.36	2.14	2.50	2.09	2.13	2.19	2.28	2.24
16	2.48	2.56	3.1	2.94	2.34	2.14	2.21	2.12	2.12	2.48	2.34	2.46
17	2.50	2.56	3.1	2.96	2.30	1.94	2.46	1.97	2.14	2.38	2.32	2.40
18	2.47	2.60	3.1	2.87	2.34	2.06	2.34	2.12	2.14	2.26	2.23	2.36
19	2.42	3.35	2.95	2.82	2.29	2.10	2.16	2.00	2.16	2.20	2.20	2.38
20	2.52	4.4	2.87	2.97	2.28	2.15	2.16	2.08	2.14	2.16	2.20	2.60
21	2.72	3.85	2.80	2.98	2.26	2.16	2.15	2.08	2.10	2.14	2.05	2.98
22	2.63	3.45	2.78	2.86	2.24	2.14	2.12	2.16	2.16	2.18	2.19	3.35
23	2.50	3.35	2.79	2.75	2.26	2.16	2.12	2.08	2.04	2.16	2.14	2.97
24	2.50	3.25	2.82	2.70	2.24	2.10	2.14	1.99	2.14	2.12	2.15	2.80
25	2.76	3.1	2.83	2.65	2.22	2.11	2.12	2.09	2.12	2.16	2.17	2.95
26	2.73	3.05	2.82	2.61	2.22	2.12	2.12	2.64	2.10	2.14	2.16	3.0
27	2.61	2.98	2.80	2.60	2.20	2.08	2.04	2.56	2.14	2.15	2.14	2.82
28	2.54	2.95	2.75	2.54	2.18	2.10	2.16	3.00	2.02	2.15	2.12	3.05
29	2.46	....	2.72	2.50	2.17	2.04	2.14	2.56	2.13	2.16	2.18	2.98
30	2.45	....	3.15	2.50	2.20	2.12	2.04	2.33	2.10	2.13	2.42	3.45
31	2.70	....	3.85	....	2.21	....	2.08	2.22	....	2.13	....	3.45

NOTE.—Ice present as follows:
1909: Dec. 10-31; slush ice and ice along shore.
1910: Dec. 8-23.
1912: Jan. 1-20 and about Feb. 4-6.
1914: Feb. 17; frozen over at riffle below gage.
1911 and 1913: No ice reported.

BIG REED ISLAND CREEK NEAR ALLISONIA, VA.

Location.—About 1,200 feet above suspension footbridge at J. P. Thomas' farm, about three-fourths mile above mouth of creek; 1½ miles from Allisonia, and half a mile above mouth of Little Reed Island Creek.

Drainage area.—291 square miles.

Records available.—July 31, 1908, to December 31, 1914.

Gage.—Vertical staff fastened to a tree on right bank; read once daily.

Discharge measurements.—Made from the footbridge or by wading.

Channel and control.—Channel at the bridge is liable to change and will overflow on right bank. Gage is above influence of backwater from New River. Control practically permanent.

Extremes of stage.—Maximum mean daily gage height: 4.8 feet, May 12, 1912. Minimum stage observed: 0.28 foot at 6 P. M., August 20, 1914.

Winter flow.—Discharge relation at times affected by ice.

Accuracy.—Gage-height record reliable.

Data insufficient for computation of discharge.

Discharge measurements of Big Reed Island Creek near Allisonia, Va., in 1908–1914.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1908				1911			
Aug. 1....	O'Neill and Chapman	0.72	384	July 19...	Horton and Bailey..	.40	172
Aug. 18...	W. M. O'Neill.......	.63	323	1913			
1909				Dec. 12...	Peterson and Walters	.60	252
June 12 ...	H. J. Jackson.....	1.05	588	Dec. 12...	.....do	.68	323
1910				1914			
Mar. 16...	C. T. Bailey........	.69	344	Oct. 7....	Mathers and Morgan	.44	182
Oct. 24....	.....do	.52	254	Oct. 7....	.....do	.44	179

Daily gage height, in feet, of Big Reed Island Creek near Allisonia, Va., for 1908–1914.

[J. P. Thomas, Arie Lilly, and K. M. Thomas, observers.]

Day	Aug.	Sept.	Oct.	Nov.	Dec.	Day	Aug.	Sept.	Oct.	Nov.	Dec.
1908						1908					
1	......	0.6	0.6	0.75	0.7	16	0.6	0.6	0.6	0.8	0.7
2	0.64	.6	.6	.8	.7	17	.65	.6	.6	.8	.7
3	.62	.6	.6	.8	.7	18	.5	.5	.6	.8	.75
4	.6	.6	.55	.8	.7	19	.6	.5	.6	1.15	.8
5	.64	.65	.5	.8	.7	20	.6	.5	.6	.85	.8
6	1.75	1.05	.5	.8	.7	21	.6	.5	.6	.8	.8
7	1.2	.8	.5	.8	1.3	22	.65	.5	.6	.8	.8
8	.9	1.3	.5	.75	1.2	23	.75	.5	.6	.8	.85
9	.9	.75	.5	.7	.95	24	.7	.5	.6	.8	.9
10	.82	.7	1.9	.7	.8	25	1.0	.5	1.15	.8	1.05
11	.74	.6	1.35	.75	.8	26	1.7	.5	.8	.8	1.15
12	.7	.6	.85	.8	.9	27	1.3	.5	.8	.75	.9
13	.68	.6	.75	.8	.8	28	.8	.85	.95	.7	.8
14	.65	.6	.7	.8	.8	29	.8	.9	1.95	.7	.8
15	.65	.6	.65	.8	.8	30	.7	.65	1.5	.7	.8
						31	.7	......	1.0	......	.85

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	......	0.8	0.9	0.8	2.05	1.0	1.15	1.15	0.6	0.5	0.6	0.5
2	......	1.15	.9	.8	1.45	.95	1.1	2.05	.5	.5	.6	.5
3	0.8	1.2	.9	.8	1.1	.95	.9	1.15	.5	.6	.6	.5
4	.8	.95	.95	.8	.95	2.15	.9	1.0	.7	.6	.6	.5
5	1.5	.9	.85	.8	.9	1.35	.8	.9	.65	.6	.5	.5
6	1.4	.8	.85	.7	.9	1.05	.9	1.0	.65	.6	.5	.5
7	1.05	.8	1.05	.7	.9	1.0	1.1	.9	.65	.6	.5	.55
8	.95	.7	1.0	.75	.8	.9	1.15	.8	.6	.5	.5	1.0
9	.9	.7	1.0	.85	.8	1.45	.9	.8	.8	.5	.5	.6
10	.85	1.05	1.0	.8	1.65	1.2	.9	.8	1.0	.6	.5	.6
11	.8	1.15	.95	.7	1.2	1.4	.8	.7	.8	1.9	.6	.55
12	.8	.9	.9	.7	1.0	1.1	.8	.7	.7	1.6	.6	.75
13	.8	.8	.9	.8	.9	1.55	.9	.8	.6	.9	.6	1.3
14	.8	.85	.9	3.35	.8	1.4	.9	.9	.6	.8	.5	1.4
15	.8	.85	.9	1.7	.8	1.5	.8	.85	.6	.7	.5	.85
16	.8	1.1	.8	1.35	.8	1.15	.8	.9	.6	.7	.5	.65
17	1.1	1.0	.8	1.15	.8	1.85	.8	.85	.9	.6	.55	.7
18	1.2	.9	.8	1.0	.8	1.75	.8	.7	.9	.6	.5	.7
19	1.0	.9	.8	1.0	.8	1.15	.7	.7	.6	.6	.5	.7
20	.9	1.25	.8	.95	1.1	1.0	.7	.7	.65	.6	.5	.6
21	.9	.95	.8	.9	2.65	1.0	.7	.6	.8	.6	.5	.7
22	.9	1.1	.9	.9	1.8	1.0	.7	.6	.7	.6	.5	.9
23	.85	1.2	.8	.9	1.25	1.0	.95	.6	.6	.6	.6	.6
24	.8	1.75	.8	.95	1.1	1.3	.8	.6	.65	.7	.5	.6
25	.8	1.75	1.25	.8	1.1	1.05	.7	.6	.6	.6	.5	.8
26	.8	1.25	1.1	.8	1.35	1.0	.7	.6	.6	.6	.5	.65
27	.8	1.05	.95	.8	1.5	1.25	.9	.6	.6	.6	.5	.75
28	.8	1.0	......	.8	1.2	1.0	1.05	.6	.5	.6	.5	.75
29	.7	......	......	.8	1.05	1.15	.9	.6	.5	.6	.5	.7
30	.7	......	......	.9	1.0	1.35	.8	.6	.5	.6	.5	.6
31	.7	......	......	......	.9	......	.8	.6	......	.6	......	.65

Daily gage height, in feet, of Big Reed Island Creek near Allisonia, Va., for 1908–1911—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
1	....	0.65	2.1	0.60	0.6	0.6	0.7	0.6	1.0	0.4	0.5	0.5
2	1.0	.75	1.35	.5	.6	.6	.6	.6	.95	.4	.5	.5
3	1.05	.95	.85	.65	.6	.6	.75	.5	.85	.4	.5	.5
4	.8	.7	.75	.95	.6	.6	.8	.5	1.2	.4	.5	.6
5	.65	.75	.7	.75	.6	.7	.65	.6	.85	.4	.5	.6
6	.65	.95	.8	.7	.6	.9	.6	.6	.65	.4	.5	1.25
7	2.0	.95	.8	.6	.6	.75	1.1	.6	.6	2.15	.5	.8
8	1.0	.95	.8	.6	.6	.65	1.1	.5	.65	1.4	.5	.6
9	.85	.85	.8	.6	.6	.65	.95	.5	.7	1.65	.5	.6
10	.65	.8	.8	.6	.6	1.05	.75	.5	.55	.85	.5	.6
11	.65	.85	.8	.6	.6	1.35	.6	.5	.5	.7	.45	.5
12	.6	.65	.7	.6	.65	2.55	1.3	.5	.5	.7	.4	.5
13	.65	.95	.7	.95	.6	3.4	1.3	.5	.5	.6	.4	.5
14	.65	.85	.7	.75	.6	2.65	1.25	.5	.5	.5	.45	.5
15	.6	.9	.7	.7	.6	1.85	.95	.5	.5	.5	.5	.6
16	.6	.95	.7	.6	.6	1.55	.8	.5	.5	.5	.5	.7
17	.6	1.45	.7	.9	.6	1.25	1.2	.5	.5	.5	.4	.6
18	.6	2.65	.7	1.1	.7	1.15	1.1	.5	.5	.5	.4	.7
19	.65	1.3	.7	.8	.6	1.1	.95	.5	.4	.55	.5	.5
20	.6	.95	.7	.8	.6	1.1	.75	.5	.4	.75	.5	.5
21	1.7	1.1	.7	.8	.7	1.2	.7	.5	.4	.6	.5	.5
22	1.3	.95	.7	.75	.7	.95	.7	.5	.4	.6	.5	.5
23	.85	.95	.6	.7	1.2	.95	.7	.5	.4	.6	.5	.6
24	.75	.95	.6	.6	1.0	1.05	.65	.5	.4	.5	.5	....
25	.7	1.0	.6	.7	1.15	.95	.6	.8	.4	.5	.5	....
26	.7	.85	.6	.8	1.2	.85	.55	.8	.4	.5	.5	....
27	.65	.85	.6	.7	.85	.8	.6	.85	.4	.5	.5	....
28	.65	1.3	.6	.7	.8	.8	.6	.6	.5	.6	.55	....
29	.65	....	.6	.6	.7	.7	.6	.5	.45	.5	.55	....
30	.65	....	.6	.6	.7	.7	.6	.65	.4	.5	.5	....
31	.6	....	.6	....	.7	....	.65	.75	....	.5	....	....
1911												
1	....	0.75	0.6	0.65	0.9	0.7	0.5	0.3	0.7	0.3	0.5	0.56
2	1.5	.65	.6	.6	.85	.6	.4	.3	.55	.4	.5	.54
3	1.6	.6	.6	.6	.7	.5	.4	.3	.55	.6	.4	.54
4	1.6	.6	.6	.65	.7	.5	.4	.3	.4	.5	.4	.52
5	.95	.6	.6	1.85	.65	.6	.95	.5	.4	.4	.4	.43
6	.8	.7	.65	1.75	.6	.65	.55	1.05	.35	.4	.55	.44
7	.8	.7	.8	1.1	.6	.75	.5	.55	.3	.4	.95	.56
8	.7	.8	.8	1.65	.6	1.05	1.05	.4	.3	.5	.6	.48
9	.7	1.2	1.15	1.25	.6	.65	.65	.4	.4	.5	.6	.46
10	.7	1.2	1.0	1.05	.6	.55	.55	.35	.55	.4	.65	.47
11	.7	.95	1.0	.9	.6	.5	.5	.3	.5	.5	.6	.48
12	.7	.8	.85	.95	.6	.5	.5	.4	.5	.5	.56	.50
13	.6	.7	.75	1.0	.75	.5	.6	.6	.4	.4	1.05	.48
14	.6	.7	.8	1.25	1.7	.5	.65	.55	.3	.4	.66	.48
15	.6	.7	.8	1.45	.95	.5	.55	.4	.3	.4	.53	.56
16	.6	.7	.7	1.4	.8	.5	.4	.4	.3	.4	.58	1.2
17	.6	.7	.6	1.05	.7	.5	.4	.35	.3	.5	.54	1.1
18	.6	.7	.65	.9	.7	.5	.4	.3	.35	[a]2.4	.54	.76
19	.6	.7	.7	.95	.6	.5	.4	.3	.3	.85	.56	.66
20	.6	.7	.75	1.05	.6	.5	.4	.3	.3	.65	.60	.60
21	.6	.7	.65	.9	.6	.5	.4	.3	.35	.6	.54	.66
22	.75	.7	.6	.8	.6	.4	.4	.3	.9	.55	.51	.94
23	.95	.6	.6	.8	.65	.4	.4	.3	.65	.85	.50	1.6
24	.75	.6	.6	.8	.6	.4	.3	.3	.5	.6	.54	.98
25	.7	.6	.6	.8	.6	.5	.35	.3	.4	.5	.62	1.2

[a] Gage height was 3.3 feet at 7 A. M., Oct. 18.

Daily gage height, in feet, of Big Reed Island Creek near Allisonia, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
26	.7	.6	.6	.7	.6	.5	.35	.65	.4	.5	.50	.94
27	.7	.6	.85	.7	.55	.6	.3	1.35	.4	.5	.50	1.0
28	.6	.6	.75	.7	.6	1.1	.3	.5	.4	.5	.52	.85
29	.6	......	.7	.7	.55	.7	.3	.55	.4	.5	.72	.80
30	1.0	......	.7	.8	.5	.55	.3	1.15	.35	.5	.66	.72
31	1.0	......	.7	......	.75	......	.3	.9	......	.5	......	......
1912												
1	0.90	0.74	0.82	1.25	0.95	0.81	1.05	0.66	0.42	0.50	0.47	0.57
2	.66	.77	.71	1.4	.88	.80	.86	.59	.35	.47	.75	.58
3	.62	.66	.80	1.35	.82	.85	.70	.50	.30	.48	.51	.60
4	.58	.70	.76	1.15	.81	.83	1.0	.73	.35	.48	.46	.54
5	.55	.82	.82	1.06	.78	.81	.77	.72	.35	.47	.48	.89
6	......	.99	.80	.99	.80	.79	1.05	.54	.37	.46	.46	.92
7	......	.99	.80	1.0	.80	.77	.75	.50	.33	.47	1.98	.88
8	......	.94	.94	1.15	.82	.74	.80	.49	.40	.45	1.53	.70
9	......	.86	1.2	1.05	.74	.71	.75	.55	.45	.43	.85	.62
10	......	.74	1.05	.99	.68	.71	.89	.56	.37	.42	.70	.58
11	......	.64	.94	.90	.79	.70	.76	.60	.35	.43	.64	.57
12	......	.56	1.05	.88	4.8	.69	.79	.48	.32	.43	.63	.55
13	......	.51	1.6	.84	2.6	.68	.73	.60	.34	.44	.66	.50
14	1.05	.51	1.2	.86	1.4	.60	.82	.52	.43	.54	.76	.49
15	1.1	.52	2.4	.86	1.4	.88	.73	.47	.45	.75	.67	.51
16	1.1	.58	2.1	.84	2.4	.78	.62	.65	.62	.50	.58	.60
17	1.1	.53	1.4	.88	2.0	.71	.70	.50	.35	.54	.44	.45
18	1.15	.58	1.15	.92	1.45	.68	.76	.48	.53	.47	.49	.50
19	1.25	.63	1.0	.84	1.25	1.05	1.1	.45	.53	.50	.57	.60
20	1.4	.60	.96	.79	1.15	.68	.68	.50	.65	.70	.55	.59
21	1.1	.71	.91	.80	1.1	.65	.62	.48	.55	.50	.50	.54
22	1.05	2.2	.86	.88	1.0	.63	.72	.47	.38	.48	.51	.49
23	1.0	.98	.86	1.0	1.0	.77	.60	.53	1.8	.45	.51	.50
24	.96	.90	1.25	.82	.96	.92	.55	.41	1.9	.50	.52	.58
25	.88	1.25	1.3	.78	.93	.74	.65	.38	1.25	.49	.50	.67
26	.80	1.2	1.1	.77	.92	.70	.62	.40	.72	.47	.49	.72
27	.79	1.7	.98	.91	.96	.68	.52	.48	.66	.45	.50	.80
28	.78	1.1	.90	.94	.88	.67	.50	.40	.62	.45	.50	.90
29	.68	.94	2.7	.88	.88	.70	.49	.40	.54	.45	.54	.89
30	1.3	......	1.7	1.25	.94	.72	.48	.49	.52	.46	.50	.72
31	.92	......	1.25	......	.87	......	.52	.44	......	.47	......	1.1
1913												
1	0.75	0.81	0.94	0.95	0.85	1.0	0.66	0.56	0.50	0.65	0.66	0.88
2	.65	.70	.81	.93	.82	.96	.70	.49	.45	.59	.65	1.25
3	.65	.81	.69	.90	.80	1.7	.71	.47	.45	.58	.64	.91
4	.87	.91	.65	.86	.78	.95	.81	.44	1.7	.56	.64	.80
5	.77	.74	.64	.87	.75	.89	.79	.43	1.15	.54	.62	.79
6	.68	.66	.60	.88	.72	.85	.64	.41	.70	.54	.62	.71
7	.64	.59	.58	.80	.74	.83	.58	.43	.56	.53	.63	.78
8	.66	.63	.57	.81	.78	.90	.57	.50	.54	.66	.69	.76
9	.63	.83	.56	.80	.72	.96	.55	.62	.64	.68	2.0	.74
10	.58	.70	.66	.80	.73	.85	.53	.57	.52	.68	1.2	.72
11	.57	.62	.87	.96	.75	.81	1.5	.58	.48	.61	.86	.74
12	.59	.64	.70	3.0	.70	.93	.88	.83	.48	.86	.81	.77
13	.69	.52	.63	2.0	.70	1.05	.80	.70	.47	.61	.78	.72
14	.60	.48	4.0	1.5	.70	.92	.61	.60	.45	.56	.76	.68
15	.53	.52	2.8	1.25	.69	.72	.60	.51	.44	.55	.73	.65
16	.55	.59	1.9	1.25	.87	.75	.60	.50	.49	.53	.72	.65
17	.54	.57	1.35	1.1	1.15	.75	.50	.47	.48	.52	.92	.64
18	.56	.55	1.1	1.0	1.0	.74	.55	.54	.84	.55	.77	.64
19	.60	.51	1.0	1.05	.81	.72	.53	.60	.80	.63	.74	.61
20	.57	.60	.98	.98	.74	.70	.61	.80	1.9	2.0	.70	.63

Daily gage height, in feet, of Big Reed Island Creek near Allisonia, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
21	.56	.80	1.0	.84	1.0	.67	.58	.55	4.0	1.15	.68	.63
22	.54	.74	1.25	.82	1.0	.67	.51	.54	1.8	.83	.67	.62
23	.52	.68	.98	.80	3.2	.96	.48	.60	1.1	.74	.67	.63
24	.57	.61	.92	.88	3.0	.95	.47	.55	.76	1.5	.64	.74
25	.56	.59	.89	.85	1.6	1.0	.50	.49	.75	1.45	.63	.74
26	.66	.58	1.1	.82	1.25	1.05	.50	.46	.75	.92	.61	1.05
27	1.0	.91	3.1	1.1	1.5	.81	.57	.48	.61	.80	.56	.76
28	1.55	1.35	1.75	.93	1.5	.73	.52	.82	.60	.80	.62	.77
29	.97	....	1.3	.91	1.2	.67	.50	.48	.63	.73	.63	.74
30	.82	....	1.1	.88	1.1	.66	.51	1.3	.60	.69	.64	.73
31	.77	....	1.05	....	1.25	....	.63	.82	....	.65	....	.69
1914												
1	0.70	1.5	0.94	1.2	0.73	0.57	0.35	0.36	0.48	0.31	0.41	1.45
2	.68	1.15	1.1	1.25	.73	.55	.77	.34	.58	.30	.42	1.3
3	.58	.96	1.25	.98	.72	.53	.45	.33	.51	.31	.42	.93
4	.88	.91	.93	.92	.71	.51	.45	.38	.44	.39	.41	.94
5	.83	.90	.89	.87	.98	.52	.45	.36	.37	.87	.41	2.8
6	.79	1.65	.90	.84	1.0	.62	.51	.37	.36	.51	.39	1.3
7	.75	1.65	.96	.82	.81	.60	.84	.35	.36	.43	.38	1.05
8	.76	1.25	.95	1.3	.79	.63	.49	.33	.70	.38	.37	.92
9	.88	1.05	.80	1.1	.76	.60	.47	.32	.67	.44	.53	.82
10	1.0	.99	.81	.94	.75	.64	.59	.65	.47	.39	.50	.83
11	.98	.97	1.05	.88	.70	.67	.46	.82	.44	.33	.44	.31
12	.82	.92	1.3	.84	.69	.95	.38	.80	.54	.31	.40	.75
13	.73	.97	1.1	.83	.72	.56	.37	.52	.46	.48	.38	.78
14	.97	1.45	1.0	.87	.70	.54	1.35	.47	.42	.48	.43	.83
15	.99	1.5	1.0	1.05	.66	.50	.76	.40	.40	.44	1.5	.73
16	.88	1.05	1.05	1.2	.66	.46	.87	.38	.36	2.4	1.15	1.1
17	.91	1.1	1.05	1.0	.65	.45	.76	.35	.37	.82	.61	1.1
18	.80	1.15	1.45	.93	.65	.44	.64	.34	.42	.64	.53	1.05
19	.76	1.25	1.1	.88	.63	.48	.50	.31	.42	.45	.51	1.0
20	1.0	1.85	1.05	1.5	.62	.49	.44	.28	.40	.51	.61	1.25
21	1.25	1.4	.97	1.1	.60	.49	.40	.30	.42	.49	.43	1.15
22	1.0	1.2	.98	.97	.60	.44	.37	.62	.37	.47	.70	1.2
23	.90	1.2	.94	.91	.58	.41	.37	.35	.38	.46	.70	.95
24	.92	1.05	.91	.87	.58	.37	.35	.31	.48	.58	.56	.91
25	1.6	.98	.90	.85	.57	.34	.34	.39	.38	.56	.61	1.55
26	1.15	.96	.88	.82	.56	.37	.37	1.0	.36	.51	.59	1.2
27	.94	.95	.87	.78	.55	.51	.60	.99	.33	.46	.57	.87
28	.87	.94	.92	.77	.54	.62	.44	1.2	.32	.43	.50	.84
29	.84	....	.89	.77	.57	.44	.40	.86	.32	.42	.47	1.0
30	.81	....	1.0	.76	.78	.37	.33	.58	.31	.42	1.7	1.55
31	2.5	....	.96	....	.60	....	.33	.51	....	.41	....	1.15

NOTE.—Ice present as follows:

1909: Slush ice and frozen along shore Dec. 10-31. Stream did not freeze across.

1910: Jan. 1-25; Feb. 7-13, and Dec. 13-24. On Dec. 24 the gage was torn away by the ice going out.

1911: Slush ice running Jan. 11 and Feb. 21. Observer reported backwater Dec. 7.

1912: Jan. 3-20 and Feb. 2-16. Observer reported backwater Jan. 18; creek frozen across at some places Jan. 20, ice 6 to 10 inches thick; backwater Feb. 5 and 6, ice about 5 inches thick.

1913: Feb. 6-15; slush ice Feb. 8; backwater Feb. 9.

1914: Jan. 14-20; Feb. 14-18; Mar. 2-3.

LITTLE RIVER NEAR COPPER VALLEY, VA.

Location.—At highway bridge about 600 feet above mouth of Indian Creek, about half a mile north of Copper Valley, and about 5 miles south of Childress.

Drainage area.—195 square miles.

Records available.—July 25, 1908, to December 31, 1914.

Gage.—Chain attached to bridge; read twice daily.

Discharge measurements.—Made from bridge.

Channel and control.—Left bank high, wooded, and not liable to overflow; right bank low and clean, and overflows. All water passes beneath the bridge. Bed composed of rocks and sand. Control section probably permanent.

Extremes of stage.—Maximum mean daily gage height: 8.1 feet, March 14, 1913. High water of about 1900 is reported to have been at a stage of approximately 12.9 feet. Minimum stage observed: 3.05 feet in August, 1911, and July, 1914.

Winter flow.—Discharge relation affected by ice for short periods.

Accuracy.—Gage-height record reliable.

Data insufficient for computations of discharge.

Discharge measurements of Little River near Copper Valley, Va., in 1908–1914.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1908				1911			
July 28....	O'Neill and Chapman	3.74	337	July 18...	Horton and Bailey.	3.25	125
Aug. 21...	W. M. O'Neill.....	3.39	182	1912			
				Sept. 21..	C. T. Bailey........	3.30	152
1909							
June 11 ...	H. J. Jackson......	4.17	538	1913			
Dec. 8.....	A. H. Horton......	3.82	337	Dec. 10...	Walters and Peterson	3.31	138
1910				1914			
Mar. 14...	C. T. Bailey........	3.60	228	Oct. 6....	Mathers and Morgan	3.47	178
Oct. 19....	.....do	3.41	155				

Daily gage height, in feet, of Little River near Copper Valley, Va., for 1908–1914.

[William J. Trail and Thomas A. DeHart, observers.]

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908							1908						
1	......	3.45	3.44	3.43	4.06	3.71	16	......	......	3.39	3.57	3.86	3.71
2	......	......	3.41	3.40	3.96	3.72	17	......	3.42	3.36	3.52	3.86	3.68
3	......	3.35	3.39	3.37	3.88	3.61	18	......	3.34	3.38	3.53	3.95	3.68
4	......	3.34	3.39	3.36	3.85	3.59	19	......	3.36	3.36	3.52	4.38	3.72
5	......	3.34	3.44	3.36	3.79	3.71	20	......	3.32	3.38	3.53	4.07	3.70
6	......	4.04	4.36	3.34	3.72	3.67	21	......	3.32	3.38	3.50	3.93	3.66
7	......	3.98	4.29	3.33	3.71	4.62	22	......	3.32	3.39	3.50	3.83	3.71
8	......	3.44	4.42	3.33	3.71	4.23	23	......	3.40	3.39	3.86	3.81	3.81
9	......	......	3.66	3.37	3.71	3.95	24	......	3.42	3.36	6.50	3.77	3.80
10	......	4.06	3.51	5.77	3.71	3.81	25	......	3.69	3.34	4.51	3.75	3.87
11	......	3.32	3.48	4.73	3.73	3.78	26	......	5.14	3.34	4.12	3.72	4.26
12	......	3.40	3.48	3.96	3.81	3.90	27	......	3.85	3.33	3.96	3.71	3.98
13	......	3.38	3.42	3.76	3.71	3.84	28	......	3.62	3.84	4.13	3.66	3.94
14	......	3.35	3.42	3.67	3.73	3.75	29	4.56	3.66	3.86	5.29	3.67	3.97
15	......	3.34	3.40	3.62	3.82	3.71	30	4.66	3.46	3.48	4.90	3.71	4.22
							31	4.02	3.49	......	4.26	......	4.88

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	4.26	3.72	3.82	3.63	4.63	3.94	4.06	4.35	3.42	3.34	3.35	3.35
2	4.25	3.85	3.83	3.61	4.22	3.97	4.01	5.52	3.38	3.31	3.35	3.35
3	3.94	3.80	3.82	3.61	3.98	3.97	3.76	4.32	3.30	3.32	3.44	3.38
4	3.98	3.90	3.92	3.61	3.81	4.93	3.65	3.98	3.42	3.29	3.38	3.35
5	4.64	3.80	3.76	3.58	3.78	4.31	3.68	3.80	3.49	3.31	3.35	3.34
6	4.57	3.85	3.82	3.58	3.73	4.07	3.85	4.12	3.41	3.34	3.32	3.30
7	4.16	3.75	4.00	3.57	3.72	3.98	4.12	3.95	3.41	3.35	3.39	3.38
8	4.00	3.68	3.93	3.55	3.71	3.94	4.05	3.66	3.51	3.32	3.39	3.60
9	3.96	3.75	3.92	3.58	3.68	4.08	3.78	3.60	3.62	3.32	3.40	3.42
10	3.91	4.30	3.86	3.55	4.14	4.03	3.76	3.55	4.22	3.30	3.41	3.40
11	3.87	3.95	3.82	3.53	3.90	4.03	3.72	3.54	3.70	4.56	3.44	3.40
12	3.81	3.78	3.75	3.53	3.74	3.98	3.68	3.58	3.56	4.44	3.41	3.51
13	3.70	3.78	3.74	3.71	3.72	4.04	3.70	3.55	3.50	3.58	3.39	3.58
14	3.75	3.75	3.80	7.03	3.70	3.95	3.78	3.56	3.46	3.45	3.36	4.48
15	3.85	3.72	3.66	4.83	3.67	3.91	3.68	3.70	3.46	3.52	3.38	3.68
16	3.95	3.92	3.66	4.35	3.64	3.90	3.64	3.92	3.49	3.49	3.40	3.50
17	4.30	3.85	3.65	4.11	3.63	4.01	3.66	3.68	3.70	3.48	3.39	3.36
18	4.35	3.75	3.63	4.01	3.62	4.18	3.60	3.55	3.55	3.44	3.35	3.48
19	4.25	3.72	3.62	3.91	3.58	3.91	3.59	3.55	3.55	3.44	3.35	3.38
20	4.20	4.08	3.63	3.91	3.74	3.86	3.52	3.49	3.49	3.42	3.32	3.50
21	4.05	3.82	3.63	3.85	7.13	3.80	3.51	3.45	3.45	3.40	3.32	3.55
22	4.00	3.92	3.70	3.83	5.38	3.79	3.52	3.45	3.60	3.42	3.35	3.38
23	3.95	4.05	3.60	3.85	4.56	3.82	3.60	3.41	3.58	3.40	3.42	3.35
24	3.95	4.15	3.60	3.95	4.26	3.88	3.58	3.44	3.50	3.45	3.40	3.45
25	3.90	4.38	3.94	3.75	4.22	3.84	3.52	3.40	3.45	3.41	3.35	3.52
26	3.88	4.10	3.82	3.78	4.64	3.79	3.49	3.45	3.40	3.40	3.35	3.48
27	3.85	3.95	3.69	3.77	4.82	3.81	3.64	3.46	3.39	3.40	3.35	3.49
28	3.78	3.88	3.88	3.75	4.31	3.75	3.73	3.44	3.36	3.36	3.35	3.53
29	3.75	....	3.80	3.74	4.13	3.90	3.68	3.41	3.36	3.35	3.36	3.45
30	3.75	....	3.70	3.77	4.02	4.02	3.80	3.46	3.35	3.40	3.35	3.45
31	3.50	....	3.66	....	4.00	....	3.66	3.42	....	3.41	....	3.45
1910												
1	3.54	3.47	4.78	3.39	3.44	3.28	3.52	3.42	4.14	3.44	3.35	3.22
2	3.72	3.73	4.54	3.49	3.43	3.28	3.47	3.41	3.78	3.35	3.37	3.22
3	3.92	3.74	4.10	3.54	3.46	3.25	3.45	3.43	3.55	3.30	3.40	3.34
4	3.78	3.93	3.90	3.80	3.46	3.22	3.67	3.43	4.01	3.27	3.38	3.32
5	3.62	3.80	3.80	3.59	3.42	3.37	3.66	3.46	3.76	3.25	3.35	3.45

Daily gage height, in feet, of Little River near Copper Valley, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
6	3.52	3.74	3.93	3.50	3.38	3.69	3.65	3.42	3.54	3.28	3.28	3.71
7	4.61	3.48	4.00	3.44	3.40	3.45	3.69	3.38	3.42	4.30	3.32	3.64
8	3.71	3.84	3.79	3.37	3.59	3.32	3.85	3.39	3.42	4.31	3.35	3.66
9	3.44	3.70	3.72	3.36	3.74	3.30	3.81	3.41	3.38	4.76	3.32	3.66
10	3.65	3.76	3.69	3.30	3.59	3.51	3.62	3.37	3.40	3.76	3.34	3.64
11	3.60	3.83	3.69	3.34	3.49	3.92	3.55	3.37	3.36	3.56	3.32	3.58
12	3.60	3.78	3.68	3.42	3.41	5.19	3.53	3.36	3.38	3.54	3.31	3.36
13	3.65	3.78	3.62	3.84	3.43	5.77	3.81	3.32	3.41	3.44	3.27	3.25
14	3.55	3.83	3.54	3.66	3.41	5.82	4.09	3.35	3.36	3.42	3.30	3.31
15	3.52	3.80	3.49	3.48	3.41	4.75	4.07	3.37	3.38	3.42	3.44	3.48
16	3.55	3.90	3.47	3.47	3.37	4.65	3.69	3.45	3.36	3.38	3.41	3.50
17	3.50	4.78	3.49	4.06	3.36	4.27	4.68	3.43	3.32	3.38	3.32	3.34
18	3.49	6.00	3.48	4.14	3.41	4.02	4.82	3.43	3.30	3.38	3.32	3.35
19	3.51	4.12	3.47	3.80	3.55	3.85	4.09	3.43	3.28	3.34	3.35	3.40
20	3.40	4.00	3.48	3.69	3.42	3.73	3.80	3.41	3.31	3.85	3.28	3.31
21	4.58	4.14	3.48	3.64	3.41	3.85	3.65	3.38	3.30	3.56	3.28	3.33
22	4.23	4.10	3.48	3.59	3.47	3.85	3.59	3.39	3.31	3.47	3.31	3.40
23	3.82	3.96	3.46	3.56	3.43	3.91	3.57	3.41	3.26	3.44	3.35	3.29
24	3.66	3.79	3.44	3.54	3.59	3.89	3.75	3.36	3.26	3.37	3.30	3.59
25	3.50	3.66	3.43	3.52	3.71	4.45	3.55	3.45	3.25	3.36	3.30	3.65
26	3.73	3.68	3.39	3.67	3.65	3.81	3.49	3.53	3.33	3.38	3.32	3.70
27	3.46	3.66	3.40	3.69	3.53	3.69	3.45	3.52	3.48	3.38	3.30	3.63
28	3.48	3.97	3.39	3.60	3.37	3.59	3.47	3.47	3.32	3.42	3.34	3.47
29	3.43	....	3.42	3.53	3.33	3.57	3.46	3.38	3.30	3.40	3.52	3.53
30	3.63	....	3.42	3.48	3.37	3.55	3.45	3.38	3.36	3.36	3.41	3.73
31	4.13	....	3.48	....	3.36	....	3.47	4.35	....	3.37	....	3.89
1911												
1	3.57	3.70	3.39	3.44	3.82	3.98	3.24	3.15	3.96	3.15	3.29	3.29
2	3.75	3.63	3.41	3.39	3.64	3.44	3.25	3.15	3.45	3.35	3.29	3.45
3	4.63	3.57	3.40	3.54	3.54	3.35	3.24	3.15	3.31	3.70	3.21	3.52
4	4.37	3.54	3.35	3.86	3.52	3.32	3.29	3.11	3.25	3.35	3.25	3.30
5	3.83	3.55	3.34	5.80	3.52	3.36	3.77	3.30	3.25	3.28	3.25	3.30
6	3.55	3.45	3.51	4.94	3.52	3.59	3.46	3.88	3.25	3.20	3.47	3.52
7	3.85	3.47	3.65	4.19	3.46	3.68	3.39	3.38	3.26	3.16	3.79	3.38
8	3.67	3.43	3.60	4.74	3.48	4.00	4.39	3.32	3.20	3.24	3.48	3.52
9	3.53	4.07	3.63	4.44	3.50	3.56	3.56	3.38	3.20	3.31	3.46	3.30
10	3.55	4.13	4.36	4.04	3.48	3.40	3.46	3.18	3.44	3.31	3.60	3.29
11	3.69	3.77	4.20	3.89	3.45	3.35	3.36	3.08	3.40	3.31	3.42	3.28
12	3.55	3.70	3.87	3.90	3.44	3.36	3.34	3.11	3.32	3.34	3.41	3.29
13	3.49	3.65	3.75	4.19	3.56	3.33	3.30	3.48	3.28	3.21	3.61	3.28
14	3.45	3.55	3.85	4.32	4.02	3.29	3.70	3.38	3.20	3.20	3.46	3.25
15	3.43	3.54	3.80	4.46	3.52	3.28	3.36	3.25	3.21	3.19	3.39	3.34
16	3.37	3.53	3.60	4.42	3.45	3.24	3.26	3.15	3.20	3.18	3.36	4.30
17	3.37	3.49	3.47	4.04	3.44	3.08	3.20	3.14	3.20	3.28	3.35	4.08
18	3.39	3.46	3.59	3.92	3.45	3.19	3.22	3.15	3.20	5.72	3.41	3.80
19	3.45	3.53	3.57	3.89	3.40	3.49	3.20	3.18	3.20	4.10	3.38	3.46
20	3.44	3.65	3.75	4.04	3.39	3.52	3.18	3.16	3.18	3.55	3.38	3.89
21	3.45	3.60	3.53	4.32	3.36	3.38	3.20	3.10	3.22	3.42	3.36	3.42
22	3.63	3.70	3.46	3.74	3.33	3.32	3.19	3.10	3.70	3.38	3.32	3.60
23	4.01	3.56	3.43	3.66	3.42	3.25	3.20	3.08	3.62	3.62	3.31	4.59
24	3.65	3.51	3.37	3.68	3.39	3.28	3.18	3.08	3.29	3.46	3.36	3.99
25	3.53	3.44	3.35	3.64	3.36	3.94	3.16	3.09	3.21	3.38	3.38	4.28
26	3.55	3.40	3.37	3.64	3.28	3.94	3.16	3.30	3.25	3.34	3.32	3.95
27	3.53	3.36	3.63	3.60	3.32	3.56	3.15	3.50	3.21	3.34	3.32	3.88
28	3.53	3.40	3.53	3.59	3.34	3.69	3.14	3.36	3.16	3.28	3.35	3.65
29	3.46	....	3.43	3.66	3.33	3.50	3.16	3.30	3.18	3.25	3.45	3.38
30	4.37	....	3.75	3.79	3.29	3.32	3.15	3.05	3.15	3.22	3.35	3.68
31	3.99	....	3.51	....	3.38	....	3.14	3.98	....	3.22	....	3.75

Daily gage height, in feet, of Little River near Copper Valley, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	3.68	3.52	3.67	4.05	3.70	3.54	4.15	3.58	3.19	3.28	3.26	3.38
2	3.52	3.71	3.48	4.25	3.68	3.58	3.73	3.41	3.17	3.26	3.38	3.34
3	3.51	3.58	3.50	4.2	3.62	3.67	3.55	3.36	3.16	3.25	3.32	3.34
4	3.49	....	3.53	3.93	3.52	3.54	3.56	3.61	3.13	3.25	3.26	3.36
5	3.22	....	3.69	3.83	3.49	3.57	3.89	3.57	3.15	3.28	3.22	3.62
6	3.25	....	3.50	3.82	3.54	3.58	4.2	3.42	3.19	3.25	3.28	3.68
7	3.7	3.60	3.62	3.87	3.54	3.69	3.65	3.37	3.29	3.20	4.75	3.58
8	3.55	....	3.82	4.0	3.50	3.53	3.59	3.36	3.47	3.20	4.2	3.42
9	....	....	4.65	3.80	3.44	3.51	3.52	3.42	3.33	3.20	3.64	3.34
10	....	....	4.15	3.69	3.40	3.48	3.72	3.47	3.25	3.20	3.44	3.31
11	....	....	3.96	3.64	3.56	3.47	3.58	3.41	3.16	3.20	3.42	3.30
12	....	....	4.3	3.66	7.3	3.45	3.72	3.36	3.09	3.18	3.36	3.30
13	3.65	....	4.8	3.68	5.0	3.46	3.61	3.39	3.15	3.20	3.38	3.31
14	....	3.50	4.4	3.68	4.25	3.51	3.77	3.85	3.13	3.35	3.48	3.35
15	....	....	5.8	3.68	4.2	3.65	3.52	3.35	3.26	3.62	3.42	3.52
16	....	....	5.3	3.66	5.4	3.59	3.47	3.33	3.16	3.38	3.32	3.38
17	....	3.42	3.83	3.70	4.95	3.51	3.37	3.32	3.16	3.25	3.31	3.38
18	....	3.62	4.05	3.76	4.3	3.53	3.39	3.25	3.29	3.22	3.30	3.35
19	....	3.61	3.94	3.58	3.99	3.65	4.2	3.31	3.73	3.28	3.29	3.36
20	4.15	3.53	3.87	3.53	3.86	3.58	3.59	3.35	3.53	3.38	3.28	3.36
21	....	3.76	3.88	3.54	3.86	3.55	3.43	3.35	3.22	3.32	3.29	3.36
22	....	5.1	3.81	3.59	3.79	3.66	3.39	3.35	3.19	3.26	3.30	3.32
23	....	3.93	3.78	3.72	3.76	3.65	3.37	3.27	3.69	3.40	3.29	3.32
24	....	3.76	4.25	3.52	3.72	4.15	3.35	3.35	4.65	3.36	3.22	3.42
25	....	4.45	4.35	3.52	3.69	3.61	3.43	3.19	3.89	3.26	3.24	3.54
26	....	4.3	4.1	3.50	3.69	3.72	3.45	3.25	3.54	3.28	3.28	3.50
27	3.54	5.1	3.90	3.70	3.64	3.63	3.47	3.27	3.78	3.24	3.28	3.62
28	3.51	4.1	3.82	3.83	3.64	3.49	3.31	3.25	3.51	3.21	3.29	3.62
29	3.62	3.91	6.3	3.73	3.68	3.46	3.27	3.21	3.40	3.22	3.36	3.62
30	4.3	....	4.6	3.86	3.74	3.46	3.28	3.22	3.32	3.22	3.40	3.65
31	3.90	....	4.2	....	3.60	....	3.31	3.21	....	3.20	....	4.02
1913												
1	3.72	3.58	3.75	3.66	3.48	3.56	3.45	3.21	3.18	3.38	3.41	3.70
2	3.45	3.42	3.54	3.62	3.44	3.52	3.42	3.22	3.19	3.30	3.38	4.25
3	3.90	3.42	3.42	3.59	3.40	3.54	4.6	3.21	3.15	3.30	3.38	3.76
4	3.86	3.45	3.40	3.56	3.41	3.59	3.94	3.18	4.05	3.30	3.36	3.62
5	3.58	3.45	3.39	3.48	3.39	3.58	3.88	3.15	3.88	3.28	3.38	3.56
6	3.52	3.44	3.35	3.42	3.39	3.48	3.48	3.15	3.46	3.25	3.36	3.50
7	3.48	3.32	3.25	3.40	3.41	3.58	3.42	3.18	3.39	3.26	3.34	3.62
8	3.44	3.40	3.28	3.39	3.42	3.64	3.34	3.26	3.31	3.29	3.46	3.68
9	3.39	3.55	3.36	3.40	3.40	3.65	3.32	3.21	3.58	3.50	5.0	3.48
10	3.34	3.60	3.38	3.46	3.41	3.52	3.29	3.85	3.42	3.82	4.1	3.45
11	3.30	3.42	3.75	3.60	3.38	3.48	3.58	3.49	3.30	3.58	3.75	3.58
12	3.32	3.39	3.50	4.65	3.35	3.64	3.80	3.40	3.25	3.62	3.58	3.50
13	3.34	3.32	3.40	4.35	3.34	3.86	3.44	3.42	3.24	3.50	3.68	3.54
14	3.32	3.42	8.1	3.95	3.31	3.52	3.34	3.32	3.21	3.38	3.60	3.54
15	3.30	3.46	5.3	3.78	3.32	3.96	3.39	3.29	3.18	3.32	3.62	3.41
16	3.30	3.48	4.7	3.92	3.66	3.41	3.36	3.28	3.25	3.29	3.55	3.40
17	3.34	3.35	4.05	3.76	3.80	3.40	3.29	3.20	3.29	3.30	3.72	3.38
18	3.32	3.25	3.79	3.71	3.94	3.39	3.30	3.17	3.48	3.30	3.62	3.40
19	3.36	3.24	3.74	3.62	3.46	3.39	3.30	3.65	3.54	3.38	3.55	3.34
20	3.31	3.28	3.75	3.58	3.36	3.35	3.29	3.45	3.54	4.25	3.50	3.34
21	3.30	3.62	3.78	3.50	3.06	3.34	3.30	3.38	7.0	4.15	3.46	3.35
22	3.30	3.56	3.82	3.48	4.05	3.31	3.28	3.32	4.9	3.63	3.44	3.35
23	3.29	3.42	3.64	3.46	6.5	3.75	3.26	3.39	3.75	3.52	3.45	3.38
24	3.31	3.34	3.60	3.45	6.2	3.65	3.25	3.38	3.48	3.50	3.41	3.60
25	3.35	3.30	3.65	3.45	4.5	3.60	3.26	3.24	3.42	4.2	3.40	3.50

Daily gage height, in feet, of Little River near Copper Valley, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
26	3.38	3.30	3.85	3.45	4.0	4.3	3.25	3.20	3.38	3.75	3.38	4.15
27	3.72	3.75	5.5	3.62	3.95	4.0	3.26	3.15	3.34	3.58	3.42	3.64
28	4.4	4.25	4.3	3.55	4.05	3.54	3.25	3.22	3.32	3.46	3.40	3.58
29	3.85	....	3.92	3.51	3.88	4.05	3.25	3.28	3.31	3.40	3.41	3.45
30	3.65	....	3.79	3.52	3.68	3.65	3.28	3.32	3.35	3.41	3.41	3.50
31	3.62	....	3.74	....	3.60	....	3.25	3.30	....	3.40	....	3.49
1914												
1	3.48	4.6	3.78	4.1	3.65	3.39	3.15	3.18	3.25	3.10	3.20	4.45
2	3.46	4.05	3.60	4.1	3.61	3.36	3.56	3.11	3.20	3.11	3.21	4.3
3	3.38	3.90	3.75	3.98	3.59	3.32	3.32	3.40	3.20	3.10	3.21	3.90
4	3.49	3.84	4.15	3.85	3.59	3.30	3.25	3.38	3.20	3.14	3.21	3.76
5	3.72	3.82	3.85	3.81	3.71	3.31	3.28	3.22	3.15	3.49	3.22	7.0
6	3.70	4.35	3.76	3.80	3.76	3.36	3.28	3.20	3.15	3.51	3.22	4.7
7	3.78	4.85	3.74	3.75	3.71	3.39	3.22	3.15	3.15	3.29	3.21	4.3
8	3.82	4.25	3.70	3.85	3.71	3.36	3.41	3.18	3.12	3.74	3.22	4.05
9	3.94	3.98	3.66	3.84	3.64	3.34	3.31	3.11	3.18	3.70	3.24	3.88
10	4.45	3.88	3.59	3.79	3.61	3.58	3.31	3.14	3.24	3.35	3.35	3.86
11	4.1	3.91	3.98	3.75	3.60	3.32	3.40	3.18	3.20	3.26	3.26	3.82
12	3.80	3.84	4.6	3.71	3.58	3.38	3.22	3.28	3.25	3.19	3.21	3.79
13	3.80	3.62	4.2	3.70	3.55	3.40	3.15	3.20	3.29	3.19	3.22	3.78
14	3.81	3.41	4.05	3.71	3.52	3.30	4.35	3.45	3.25	3.22	3.22	3.78
15	3.84	4.35	4.1	4.3	3.50	3.25	3.95	3.25	3.24	3.30	4.3	3.48
16	3.85	4.1	4.1	4.3	3.45	3.24	3.78	3.20	3.21	5.6	4.15	3.48
17	3.81	4.0	4.0	3.96	3.45	3.20	3.60	3.19	3.20	4.05	3.56	3.80
18	3.84	4.05	4.4	3.88	3.48	3.20	3.48	3.14	3.38	3.55	3.38	3.79
19	3.76	4.65	4.2	3.81	3.46	3.21	3.32	3.10	3.42	3.46	3.38	3.81
20	3.88	5.4	4.15	4.05	3.46	3.26	3.21	3.12	3.32	3.39	3.38	4.1
21	4.4	4.7	3.95	4.0	3.45	3.25	3.18	3.19	3.24	3.36	3.40	4.3
22	3.92	4.35	3.98	3.86	3.42	3.24	3.15	3.16	3.20	3.29	3.45	4.35
23	3.68	4.2	3.95	3.79	3.42	3.20	3.12	3.18	3.19	3.29	3.62	4.0
24	3.72	4.05	3.92	3.75	3.41	3.20	3.10	3.16	3.14	3.30	3.55	4.1
25	4.45	4.0	3.86	3.74	3.40	3.16	3.06	3.30	3.15	3.40	3.42	4.0
26	4.0	3.98	3.80	3.71	3.39	3.15	3.10	3.76	3.14	3.38	3.45	4.15
27	3.82	3.90	3.80	3.70	3.38	3.14	3.28	3.80	3.18	3.29	3.44	3.95
28	3.74	3.89	3.81	3.69	3.35	3.30	3.30	5.0	3.11	3.25	3.32	3.98
29	3.68	....	3.81	3.66	3.36	3.22	3.19	4.6	3.11	3.25	3.28	4.05
30	3.68	....	3.88	3.65	3.35	3.15	3.15	3.52	3.10	3.24	3.75	4.4
31	5.1	....	3.98	....	3.38	....	3.11	3.32	....	3.22	....	4.3

NOTE.—Ice present on following dates:

1909: Dec. 10-31; river frozen over Dec. 23; thickness of ice, 0.25 foot Dec. 26.
1910: Jan. 1-25; Feb. 7-17, and Dec. 1-24.
1911: No reports concerning ice.
1912: Jan. 6-29; Feb. 4-16. River reported frozen over Jan. 13 and 20 (ice 5 to 6 inches thick); also Feb. 7 and 14 (ice about 5 inches thick). Gage readings Jan. 7 and 8 are to top of ice.
1913: Feb. 7-9 and 13-15.
1914: Jan. 13-20; Feb. 15-18.

WALKER CREEK AT STAFFORDSVILLE, VA.

Location.—At highway bridge at Staffordsville, 500 feet below mouth of Whitley Creek.

Drainage area.—277 square miles.

Records available.—July 24, 1908, to December 31, 1914.

Gage.—Chain attached to bridge; read twice daily.

Discharge measurements.—Made from the bridge.

Channel and control.—Banks high, rocky, and not likely to overflow. Bed rocky and uneven; control section practically permanent.

Extremes of discharge.—Maximum mean daily gage height: 13.4 feet, March 27, 1913. Minimum stage observed: 2.64 feet at 7 P. M., August 5, 1914.

Winter flow.—Discharge relation probably not affected by ice.

Regulation.—A dam and power plant 300 feet above station may affect normal flow at low water.

Accuracy.—Gage-height record reliable.

Data insufficient for computation of discharge.

Discharge measurements of Walker Creek at Staffordsville, Va., in 1908–1914.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1908				1911			
July 24	O'Neill and Chapman	3.24	113	July 16	Horton and Bailey	3.34	136
Aug. 22	W. M. O'Neill	3.02	59	1912			
				Apr. 3	J. G. Mathers	6.41	1,860
1909				Apr. 4	do	5.88	1,460
June 9	H. J. Jackson	5.75	1,480	Sept. 30	C. T. Bailey	3.42	151
June 23	do	3.66	256				
Dec. 6	A. H. Horton	2.94	72	1913			
				Dec. 9	Peterson and Walters	3.46	165
1910							
Mar. 12	C. T. Bailey	4.10	358	1914			
Apr. 29	do	4.30	476	Oct. 19	Mathers and Morgan	3.08	75.4
Oct. 18	do	2.96	56.6	Oct. 19	do	3.08	76.8

Daily gage height, in feet, of Walker Creek at Staffordsville, Va., for 1908–1914.

[J. D. Worley, W. E. Durham, and J. F. Durham, observers.]

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908							1908						
1	......	3.15	3.2	3.0	4.55	3.55	16	......	3.15	3.2	3.25	3.4	4.25
2	......	3.05	3.1	3.0	4.25	3.78	17	......	3.15	3.15	3.2	3.45	4.2
3	......	3.05	3.1	3.0	3.95	3.88	18	......	3.2	3.1	3.15	3.6	4.05
4	......	3.0	3.1	3.0	3.85	3.75	19	......	3.2	3.1	2.15	4.55	3.92
5	......	3.1	3.15	3.0	3.7	3.75	20	......	3.05	3.05	3.15	4.5	4.35
6	......	3.1	3.75	3.0	3.6	3.75	21	......	3.0	3.0	3.15	4.2	3.75
7	......	3.05	3.7	3.0	3.45	4.2	22	......	3.01	3.0	3.1	3.9	3.8
8	......	3.05	3.5	3.0	3.45	5.55	23	......	3.15	3.0	3.1	3.85	3.85
9	......	3.4	3.4	3.05	3.4	4.75	24	3.22	3.05	3.0	3.9	3.75	3.75
10	......	3.45	3.3	3.95	3.35	4.48	25	3.31	3.15	3.0	4.1	3.7	3.85
11	......	3.3	3.3	4.2	3.35	4.25	26	3.4	3.6	3.05	3.7	3.7	6.3
12	......	3.15	3.3	3.7	3.35	5.3	27	3.25	3.65	3.05	3.55	3.55	5.25
13	......	3.1	3.2	3.5	3.4	5.4	28	3.35	3.45	3.25	3.6	3.48	4.95
14	......	3.0	3.25	3.3	3.45	4.85	29	3.3	3.3	3.15	5.25	3.45	5.25
15	......	3.15	3.2	3.3	3.45	4.48	30	3.25	3.25	3.0	6.5	3.48	5.55
							31	3.2	3.15	......	5.2	......	7.0

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	6.10	3.75	4.30	4.50	6.90	4.20	3.68	3.44	2.88	3.42	3.31	3.02
2	5.35	3.78	4.10	4.35	5.92	3.98	4.02	3.78	2.87	3.88	3.28	3.02
3	5.00	3.80	4.00	4.28	5.22	4.05	3.70	3.48	2.88	3.34	3.25	3.09
4	4.75	3.78	4.20	4.08	4.85	4.92	3.42	3.36	2.83	3.34	3.23	3.09
5	6.82	3.75	4.15	3.98	4.55	5.00	3.36	3.30	3.04	3.30	3.20	3.06
6	6.45	3.75	4.28	3.88	4.32	4.65	3.45	3.28	3.00	3.30	3.21	3.00
7	6.55	....	4.85	3.78	4.10	4.28	4.05	3.31	2.97	3.28	3.25	3.14
8	5.05	3.65	5.50	3.68	4.00	4.12	4.70	3.32	2.91	3.24	3.23	3.37
9	4.80	3.72	5.52	3.64	3.90	5.00	4.27	3.28	3.14	3.20	3.23	3.86
10	4.58	6.12	5.45	3.60	5.32	5.15	3.94	3.22	4.06	3.20	3.29	3.22
11	4.40	5.68	5.22	3.55	5.72	4.52	3.72	3.14	3.75	5.00	3.25	3.22
12	4.30	4.98	4.90	3.45	4.92	4.20	3.62	3.03	3.42	5.92	3.21	3.21
13	4.12	4.72	4.66	3.45	4.52	4.25	3.58	3.05	3.20	4.72	3.23	3.45
14	4.05	4.50	4.55	6.70	4.30	4.50	3.56	3.16	3.14	4.26	3.20	3.26
15	4.08	4.30	4.32	5.72	4.12	4.48	3.49	3.26	3.10	4.21	3.21	4.05
16	4.68	4.38	4.20	5.02	4.02	4.15	3.40	3.46	4.57	4.05	3.17	3.82
17	5.58	4.52	4.08	4.70	3.75	4.80	3.40	3.46	5.44	3.89	3.16	3.64
18	5.38	4.38	3.98	4.42	3.70	4.40	3.33	3.34	7.03	3.79	3.13	3.56
19	5.22	4.38	3.90	4.28	3.65	4.05	3.27	3.23	4.99	3.73	3.11	3.49
20	5.10	4.90	3.70	4.15	3.70	3.88	3.22	3.16	4.32	3.63	3.11	3.30
21	5.05	4.70	3.70	4.15	5.18	3.75	3.20	3.08	4.03	3.63	3.11	3.12
22	4.90	4.60	4.10	4.18	6.02	3.65	3.14	3.04	3.83	3.57	3.12	3.16
23	4.75	4.38	4.35	4.25	5.16	3.58	3.19	3.04	3.70	3.55	3.18	3.16
24	4.62	4.45	4.25	4.18	4.70	3.55	3.32	2.96	5.15	3.56	3.15	3.21
25	4.45	4.75	5.48	4.02	4.42	3.55	3.24	2.93	4.50	3.51	3.11	3.38
26	4.38	4.65	5.72	3.98	5.22	3.48	3.16	2.94	4.12	3.47	3.07	3.24
27	4.25	4.50	5.15	3.92	7.95	3.55	3.14	3.06	3.87	3.41	3.12	3.17
28	4.12	4.35	5.60	3.90	5.70	3.45	3.20	2.92	3.72	3.32	3.09	3.26
29	4.05	....	5.65	3.78	5.10	3.68	3.26	3.10	3.60	3.33	3.07	3.14
30	4.05	....	5.12	4.90	4.75	3.75	3.22	2.92	3.52	3.31	3.07	2.96
31	3.72	....	4.78	....	4.45	....	3.15	2.89	....	3.31	....	3.07
1910												
1	3.18	3.64	4.62	3.30	4.02	3.36	3.44	3.08	3.08	2.94	2.92	3.06
2	3.29	3.68	4.84	3.31	3.87	3.33	3.38	3.08	3.12	2.93	2.99	2.94
3	3.66	3.86	4.66	3.37	3.76	3.27	3.39	3.02	3.40	2.92	2.92	2.90
4	3.81	4.28	4.46	3.50	3.74	3.26	3.46	3.15	3.40	2.90	2.96	2.99
5	3.60	4.25	4.37	3.52	3.70	3.41	3.54	3.16	3.36	2.92	2.92	3.02

Daily gage height, in feet, of Walker Creek at Staffordsville, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
6	3.68	4.14	3.51	3.42	3.60	4.00	3.56	3.10	3.22	2.86	2.86	3.14
7	5.65	3.70	4.94	3.34	3.61	3.99	3.64	3.12	3.16	2.92	2.85	3.39
8	5.08	3.95	4.65	3.30	3.78	3.73	3.86	3.11	3.04	3.04	2.86	3.22
9	4.46	3.90	4.54	3.30	3.79	3.62	3.58	3.16	3.04	3.16	2.95	3.13
10	4.06	3.81	4.36	3.30	3.77	3.82	3.51	3.10	3.00	3.12	2.90	3.10
11	3.86	3.71	4.17	3.24	3.70	5.34	3.40	3.00	2.99	3.03	2.88	3.10
12	3.92	3.52	4.06	3.36	3.68	5.50	3.70	3.00	3.00	3.00	2.94	3.05
13	3.78	3.74	3.96	5.00	3.68	8.25	3.74	2.92	3.01	2.95	2.90	2.98
14	3.70	3.61	3.86	4.54	3.64	7.71	3.60	2.90	2.99	2.94	2.82	2.89
15	3.65	3.72	3.82	4.20	3.59	6.42	3.50	2.91	2.96	2.88	2.90	2.96
16	3.52	3.92	3.74	4.03	3.55	5.77	3.42	2.92	3.00	2.90	2.91	2.99
17	3.56	5.28	3.72	4.19	3.52	5.82	3.54	2.90	2.92	2.84	2.94	2.90
18	3.61	6.52	3.63	4.64	3.54	5.30	3.76	2.88	2.86	2.88	2.94	3.02
19	3.98	5.30	3.62	4.52	3.61	4.80	3.70	2.80	2.92	2.90	2.88	3.05
20	4.03	4.82	3.60	4.35	3.59	4.62	3.64	2.86	2.96	2.98	2.91	3.05
21	6.08	4.66	3.60	4.21	3.60	4.42	3.46	3.01	2.95	2.97	2.86	2.91
22	6.15	4.56	3.56	4.08	3.57	4.27	3.38	2.96	2.84	3.00	2.89	2.90
23	5.10	4.31	3.51	3.99	3.50	4.04	3.32	2.94	2.72	2.97	2.92	3.14
24	4.62	4.16	3.48	4.03	3.48	3.93	3.26	2.89	2.92	2.89	2.83	3.29
25	4.36	4.04	3.46	4.04	3.74	3.86	3.24	2.89	2.85	2.96	2.87	3.41
26	4.16	4.00	3.40	4.28	3.82	3.78	3.20	2.98	2.90	2.98	2.90	3.36
27	4.05	3.94	3.36	4.32	3.74	3.68	3.18	3.00	2.94	2.97	2.97	3.34
28	3.98	3.97	3.39	4.32	3.60	3.62	3.14	3.06	2.95	2.94	3.00	3.31
29	4.00	....	3.40	4.22	3.50	3.56	3.14	3.02	2.90	2.96	3.05	3.32
30	3.76	....	3.38	4.14	3.50	3.51	3.11	3.00	2.99	2.90	3.10	3.60
31	3.92	....	3.34	....	3.46	....	3.10	3.12	....	2.93	....	3.80
1911												
1	3.90	4.98	3.51	4.16	3.90	3.54	3.22	2.90	3.54	2.80	3.30	3.24
2	5.76	4.60	3.52	4.06	3.84	3.42	3.13	2.86	3.38	3.06	3.22	3.24
3	6.62	4.36	3.48	4.14	3.72	3.28	3.07	2.88	3.22	4.27	3.20	3.26
4	5.82	4.18	3.44	5.65	3.68	3.19	3.22	2.89	3.10	3.72	3.20	3.21
5	4.70	4.05	3.40	6.24	3.60	3.20	3.26	3.19	3.02	3.43	3.20	3.20
6	4.26	3.90	3.92	6.10	3.60	3.16	3.22	3.17	3.10	3.28	3.35	3.15
7	3.95	3.84	5.38	5.52	3.54	3.16	3.20	3.02	3.08	3.20	3.92	3.18
8	3.92	3.94	4.95	5.70	3.54	3.18	3.56	3.10	3.06	3.20	3.86	3.16
9	3.70	5.62	5.30	5.85	3.55	3.20	3.22	2.98	3.00	3.18	3.94	3.16
10	3.52	6.35	6.90	5.46	3.53	3.12	3.12	2.94	2.96	3.26	4.06	3.17
11	3.46	5.22	6.38	5.07	3.50	3.05	3.34	2.88	3.00	3.56	3.93	3.19
12	3.49	4.76	5.36	4.90	3.50	3.04	3.30	2.88	3.02	3.57	3.82	3.13
13	3.40	4.42	5.05	4.82	3.44	3.00	3.38	3.12	3.07	3.44	3.82	3.18
14	3.42	4.28	5.37	5.06	3.42	3.00	3.48	3.52	2.99	3.32	3.80	3.14
15	3.38	4.10	5.07	5.45	3.40	3.00	3.48	3.20	2.96	3.24	3.78	3.18
16	3.30	3.95	4.71	5.62	3.36	2.98	3.30	3.08	2.98	3.20	3.70	3.32
17	3.32	3.82	4.42	5.22	3.34	2.94	3.24	2.95	2.94	3.98	3.65	3.42
18	3.34	3.74	4.26	4.85	3.32	3.03	3.14	2.94	2.96	7.95	3.59	3.40
19	3.30	3.74	4.22	4.64	3.32	3.10	3.10	2.92	2.95	5.44	3.68	3.32
20	3.26	3.88	4.30	4.76	3.30	3.58	3.04	2.85	2.93	4.52	3.64	3.30
21	3.32	3.98	4.21	4.80	3.25	3.68	3.00	2.90	2.90	4.12	3.61	3.30
22	3.56	3.82	4.08	4.70	3.26	3.28	3.06	2.85	2.96	3.94	3.58	3.45
23	4.90	3.88	4.01	4.50	3.22	3.18	2.95	2.78	3.10	3.90	3.51	5.92
24	4.46	3.77	3.90	4.30	3.22	3.19	2.90	2.84	3.10	3.76	3.50	4.96
25	4.15	3.72	3.81	4.16	3.20	3.16	2.84	2.86	2.99	3.61	3.46	5.01
26	4.02	3.68	3.74	4.04	3.16	3.26	2.84	2.90	2.94	3.55	3.42	4.73
27	4.00	3.63	4.73	3.94	3.16	3.19	2.82	2.87	2.92	3.50	3.40	4.70
28	3.93	3.58	4.73	3.89	3.18	3.27	2.82	3.26	2.88	3.47	3.39	4.48
29	3.92	....	4.50	3.84	3.13	3.60	2.92	3.08	2.90	3.40	3.30	4.25
30	6.06	....	4.48	3.84	3.09	3.36	2.82	3.20	2.91	3.36	3.29	4.10
31	5.75	....	4.31	....	3.14	....	2.78	3.56	....	3.33	....	4.11

Daily gage height, in feet, of Walker Creek at Staffordsville, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	4.05	4.5	4.4	5.8	4.9	3.49	4.7	3.52	3.16	3.49	3.04	3.14
2	3.98	4.35	4.15	6.4	4.65	3.47	4.6	3.50	3.12	3.42	3.04	3.16
3	4.0	3.88	4.15	6.8	4.4	3.43	4.25	3.35	3.18	3.34	2.99	3.16
4	3.94	3.94	4.05	5.7	4.25	3.41	4.25	3.34	3.15	3.32	3.05	3.22
5	3.60	3.64	3.98	5.3	4.1	3.44	5.1	3.30	3.04	3.26	3.02	3.35
6	3.37	2.78	4.0	4.95	4.05	3.40	5.3	3.28	3.02	3.23	3.04	3.50
7	3.62	3.63	4.05	4.75	4.05	3.33	4.6	3.26	2.94	3.20	3.82	3.66
8	3.52	3.73	4.7	4.55	4.05	3.29	4.2	3.18	....	3.16	4.9	3.61
9	3.59	3.65	5.7	4.35	3.90	3.27	4.0	3.20	3.44	3.14	4.25	3.54
10	3.54	3.44	5.4	4.25	3.79	3.21	4.2	3.24	3.26	3.14	3.93	3.46
11	3.48	3.48	4.95	4.15	3.79	3.19	5.2	3.26	3.08	3.10	3.72	3.42
12	3.50	3.44	5.0	4.05	5.2	3.17	4.45	3.22	3.05	3.08	3.58	3.36
13	3.40	3.44	7.9	3.99	5.55	3.17	4.35	3.18	3.01	3.11	3.50	3.08
14	3.27	3.42	6.9	3.97	4.75	3.17	4.0	3.18	3.00	3.12	3.50	3.20
15	3.88	3.46	8.8	3.91	4.65	3.19	3.87	3.21	3.01	3.22	3.44	3.20
16	3.27	3.44	7.7	3.91	7.1	3.19	3.71	3.17	3.00	3.24	3.32	3.27
17	3.30	3.47	6.2	3.94	6.5	3.20	3.58	3.15	3.06	3.14	3.30	3.24
18	3.36	3.53	5.6	3.92	5.4	3.23	3.52	3.10	3.15	3.10	3.26	3.24
19	3.61	3.60	5.2	3.89	4.95	3.39	3.54	3.51	3.61	3.18	3.22	3.22
20	4.55	3.78	4.9	3.87	4.6	3.30	3.47	3.30	3.86	3.20	3.21	3.20
21	4.4	4.8	4.7	3.85	4.4	3.26	3.43	3.31	3.21	3.22	3.19	3.14
22	4.2	6.6	4.5	3.85	4.25	3.15	3.40	3.38	3.12	3.21	3.20	3.14
23	4.05	5.2	4.35	4.0	4.05	3.15	3.43	3.34	4.7	3.16	3.18	3.04
24	3.97	4.75	4.55	3.91	3.93	3.18	3.39	3.44	5.8	3.15	3.16	3.11
25	3.91	4.85	5.3	3.87	3.87	4.5	3.46	3.32	4.95	3.13	3.15	3.02
26	3.86	4.95	5.1	3.85	3.89	4.35	3.60	3.26	4.25	3.08	3.11	3.00
27	4.3	6.1	4.8	4.75	3.75	5.0	3.40	3.30	4.7	3.05	3.12	3.29
28	4.3	5.1	4.6	5.7	3.69	6.2	3.32	3.32	4.0	3.06	3.14	3.08
29	4.25	4.7	9.2	5.2	3.67	5.9	3.23	3.23	3.76	3.02	3.08	3.20
30	5.6	....	6.8	5.2	3.65	4.8	3.24	3.20	3.62	3.06	3.08	3.66
31	5.0	....	5.8	....	3.57	....	3.37	3.22	....	3.05	....	5.20
1913												
1	4.5	4.45	5.0	4.8	3.62	4.85	3.58	3.01	3.08	2.96	3.06	3.80
2	4.1	4.3	4.7	4.55	3.58	4.4	3.42	3.28	2.95	2.98	3.02	4.1
3	4.15	4.3	4.25	4.35	3.55	4.2	3.41	3.02	2.92	2.97	3.00	3.95
4	4.3	4.4	4.1	4.25	3.50	4.25	4.05	2.95	2.94	2.94	2.99	3.68
5	4.15	4.3	4.0	4.1	3.50	4.1	5.4	2.91	2.94	2.87	2.96	3.58
6	4.05	4.25	3.94	3.99	3.44	3.90	4.2	2.90	2.95	2.85	2.91	3.55
7	4.05	4.0	3.75	3.83	3.50	3.80	3.75	2.96	2.92	2.86	2.91	3.50
8	4.05	3.80	3.74	3.84	3.48	4.25	3.52	3.01	2.92	2.86	3.02	3.58
9	4.0	3.78	3.70	3.79	3.44	4.25	3.42	3.02	2.89	2.90	4.1	3.47
10	3.95	4.8	3.76	3.76	3.40	4.05	3.34	3.03	2.86	2.88	3.86	3.42
11	3.90	3.80	3.86	3.85	3.34	3.85	3.32	2.96	2.87	2.91	3.65	3.42
12	3.94	3.81	3.88	4.7	3.30	3.89	3.65	3.05	2.82	2.82	3.43	3.36
13	4.6	3.65	3.89	7.8	3.32	3.90	3.64	3.30	2.85	2.80	3.38	3.30
14	4.35	3.56	6.6	6.2	3.32	3.74	3.36	3.32	2.80	2.82	3.34	3.24
15	4.1	3.61	7.6	5.5	3.32	3.61	3.40	3.16	2.78	2.82	3.40	3.22
16	3.98	3.68	6.8	5.2	3.38	3.50	3.32	3.04	2.82	2.76	3.44	3.20
17	3.88	3.66	5.5	5.0	3.46	3.46	3.28	2.97	2.86	2.85	3.47	3.21
18	3.82	3.58	4.95	4.75	3.47	3.57	3.22	2.98	2.90	2.88	3.70	3.18
19	3.74	3.50	4.65	4.55	3.39	3.54	3.20	3.02	2.98	2.91	3.62	3.14
20	3.68	3.52	4.5	4.35	3.32	3.44	3.14	4.0	3.02	3.45	3.49	3.16
21	3.60	3.59	4.35	4.2	3.99	3.38	3.18	3.32	3.14	3.45	3.40	3.11
22	3.62	3.59	4.3	4.05	3.84	3.32	3.11	3.20	3.50	3.22	3.30	3.10
23	3.60	3.50	4.05	4.0	5.6	3.64	3.08	3.16	3.38	3.08	3.28	3.11
24	3.65	3.56	4.0	3.90	7.2	3.98	3.09	3.17	3.15	3.15	3.20	3.14
25	3.76	3.58	3.99	3.83	5.5	3.93	3.12	3.06	3.04	3.62	3.14	3.28

Daily gage height, in feet, of Walker Creek at Staffordsville, Va., for 1908–1914—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
26	3.83	3.53	4.3	3.80	4.8	3.70	3.02	3.00	2.99	3.60	3.12	3.74
27	4.6	4.35	13.4	3.85	5.6	3.72	3.01	2.94	2.94	3.46	3.12	3.72
28	5.9	5.6	7.8	3.81	6.1	3.82	3.02	2.92	2.88	3.34	3.14	3.64
29	5.1	....	6.1	3.80	5.2	3.58	3.08	2.92	2.90	3.25	3.10	3.62
30	4.7	....	5.5	3.74	4.8	3.46	3.02	2.98	2.95	3.11	3.10	3.60
31	4.5	....	5.2	....	5.6	....	3.04	3.15	....	3.08	....	3.64
1914												
1	3.72	5.7	4.55	6.4	3.67	3.00	2.77	2.70	3.02	2.72	2.70	4.45
2	3.66	4.9	4.3	6.2	3.62	3.04	2.85	2.68	2.91	2.77	2.70	5.0
3	3.58	4.55	4.3	5.6	3.59	2.98	2.83	2.66	2.88	2.70	2.72	5.0
4	3.50	4.35	4.25	5.1	3.60	2.94	2.79	2.68	2.82	2.78	2.71	4.65
5	3.86	4.3	4.25	4.8	3.66	2.95	2.84	2.67	2.80	2.78	2.69	8.6
6	3.77	4.65	4.3	4.55	3.70	3.00	2.80	2.66	2.79	2.84	2.68	5.9
7	3.76	6.6	4.25	4.4	3.66	3.00	2.80	2.67	2.78	2.80	2.68	5.1
8	3.78	5.9	4.2	4.4	3.60	3.02	2.76	2.75	2.82	2.94	2.71	4.6
9	4.25	5.1	4.1	4.3	3.60	3.00	2.88	2.75	2.73	2.82	2.68	4.3
10	6.0	4.75	3.90	4.15	3.54	3.00	2.82	2.81	2.78	2.81	2.71	4.0
11	5.2	4.6	5.4	4.1	3.48	2.91	2.75	2.75	2.80	2.82	2.70	3.84
12	4.75	4.35	6.5	4.05	3.44	2.94	2.85	2.82	2.84	2.74	2.67	3.70
13	4.0	4.15	5.6	3.96	3.40	2.95	2.86	2.83	2.91	2.76	2.74	3.65
14	3.99	4.0	5.2	3.90	3.38	3.02	3.15	2.85	2.88	2.95	2.70	3.62
15	4.1	4.1	5.2	4.3	3.33	2.94	3.32	2.83	2.82	2.82	2.95	3.18
16	4.0	3.96	5.4	5.3	3.32	2.88	3.15	2.76	2.82	3.86	3.35	3.28
17	4.1	3.72	5.7	5.0	3.30	2.86	3.00	2.72	2.78	3.70	3.22	3.30
18	4.1	4.05	5.7	4.65	3.24	2.84	2.94	2.75	2.78	3.35	3.05	3.27
19	3.98	5.4	5.2	4.45	3.22	2.85	2.93	2.71	2.82	3.13	2.96	3.38
20	4.15	7.2	4.9	4.85	3.22	2.84	2.85	2.72	2.80	2.96	2.92	3.78
21	5.8	6.1	4.45	5.0	3.20	2.91	2.80	2.72	2.76	2.93	2.78	4.8
22	5.2	5.5	4.45	4.75	3.18	2.96	2.76	2.72	2.78	2.86	2.86	5.5
23	4.6	5.45	4.5	4.5	3.17	2.94	2.73	2.75	2.78	2.84	2.84	4.8
24	4.4	5.2	4.5	4.35	3.16	2.85	2.74	2.72	2.80	2.83	2.84	4.4
25	5.4	4.75	4.5	4.25	3.11	2.98	2.73	2.95	2.82	2.86	2.78	....
26	4.95	4.65	4.55	4.15	3.10	2.90	2.72	3.05	2.80	2.80	2.82	....
27	4.65	4.55	4.6	3.99	3.10	2.75	2.71	3.38	2.82	2.79	2.81	....
28	4.3	4.55	4.5	3.93	3.10	2.80	2.70	3.88	2.80	2.76	2.82	3.80
29	4.15	....	4.4	3.84	3.05	2.75	2.71	3.66	2.79	2.79	2.85	4.15
30	4.05	....	4.7	3.75	3.04	2.74	2.75	3.36	2.80	2.77	3.18	5.5
31	4.5	....	5.8	....	3.02	....	2.72	3.18	....	2.74	....	5.3

NOTE.—No reports regarding ice in stream have been made by the observer. It is probable that the discharge relation was not affected by ice.

WOLF CREEK NEAR NARROWS, VA.

Location.—At highway bridge 1,500 feet below the New River, Holston & Western Railroad bridge, 2½ miles above mouth of Mill Creek, and 3 miles above Narrows.

Drainage area.—223 square miles.

Records available.—July 22, 1908, to December 31, 1914.

Gage.—Chain attached to bridge; read twice daily.

Discharge measurements.—Made from the bridge.

Channel and control.—Right bank high, rocky, and not likely to overflow; left bank may overflow at extreme stages. Bed of stream is clean and broken by limestone ledges. Control section practically permanent.

Extremes of stage.—Maximum mean daily gage height: 10.2 feet, March 27, 1913; highest water, date unknown, approximately 15.5 feet on present gage. Minimum stage observed: 2.18 feet, August 21-22, 1914.

Winter flow.—Discharge relation probably not affected by ice.

Accuracy.—Gage-height record reliable.

Data insufficient for computation of discharge.

Discharge measurements of Wolf Creek near Narrows, Va., in 1908-1914.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1908				1911			
July 22	O'Neill and Chapman	2.72	92	July 15	Horton and Bailey	2.69	71
Aug. 24	W. M. O'Neill	2.66	64	1912			
				Sept. 19	C. T. Bailey	2.76	88
1909							
June 8	H. J. Jackson	3.33	230	1913			
June 24	do	3.12	160	Dec. 8	Walters and Peterson	3.10	159
1910							
Mar. 11	C. T. Bailey	3.71	345	1914			
Mar. 21	do	3.22	194	Oct. 24	Mathers and Morgan	2.52	51.9
Apr. 28	do	4.00	508				
Oct. 18	do	2.42	36.3	Oct. 24	do	2.53	50.9

Daily gage height, in feet, of Wolf Creek near Narrows, Va., for 1908–1914.

[John A. Hale, observer.]

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908							1908						
1	......	2.64	2.64	2.58	3.84	3.09	16	......	2.56	2.66	2.68	2.99	3.76
2	......	2.62	2.64	2.57	3.54	3.60	17	......	2.54	2.64	2.60	3.02	3.62
3	......	2.58	2.59	2.56	3.38	3.47	18	......	2.55	2.62	2.59	3.15	3.52
4	......	2.56	2.54	2.51	3.28	3.38	19	......	2.62	2.59	2.58	3.70	3.59
5	......	2.56	2.63	2.50	3.18	3.32	20	......	2.60	2.59	2.56	3.62	3.50
6	......	2.62	4.35	2.47	3.09	3.32	21	......	2.58	2.58	2.57	3.50	3.41
7	......	2.62	3.45	2.48	3.04	3.87	22	2.72	2.60	2.56	2.56	3.38	3.42
8	......	2.60	3.19	2.49	3.99	4.72	23	2.72	2.68	2.57	2.58	3.32	3.46
9	......	2.89	3.04	2.52	2.94	4.18	24	2.72	2.62	2.56	3.02	3.23	3.37
10	......	2.98	2.92	2.72	2.91	3.88	25	2.72	2.64	2.54	3.24	3.14	3.50
11	......	2.82	2.85	3.28	2.94	3.65	26	2.68	2.99	2.52	2.96	3.06	5.37
12	......	2.72	2.82	2.95	3.01	5.12	27	2.64	3.12	2.51	2.84	3.00	4.53
13	......	2.66	2.81	2.82	3.02	4.84	28	2.74	2.90	2.55	2.82	2.94	4.35
14	......	2.59	2.72	2.72	3.00	4.30	29	2.82	2.77	2.54	3.84	2.98	4.79
15	......	2.57	2.74	2.66	3.04	4.01	30	2.74	2.71	2.58	5.09	3.00	5.01
							31	2.71	2.73	......	4.32	......	6.52

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	5.38	3.28	3.88	4.14	7.32	3.55	3.22	3.18	2.64	2.72	2.70	2.60
2	4.69	3.34	3.84	3.98	5.82	3.42	3.14	3.28	2.62	2.69	2.70	2.58
3	4.34	3.28	3.80	3.88	4.99	3.39	3.07	3.18	2.60	2.69	2.70	2.58
4	4.11	3.25	4.10	3.78	4.52	3.71	2.98	3.08	2.65	2.66	2.68	2.57
5	4.66	3.28	4.00	3.65	4.25	3.76	2.92	3.01	2.82	2.64	2.68	2.56
6	4.88	3.42	4.04	3.54	4.08	3.67	3.00	2.94	2.72	2.64	2.66	2.56
7	4.41	3.48	4.76	3.50	3.84	3.51	4.04	3.42	2.70	2.59	2.66	2.62
8	4.14	3.44	4.99	3.44	3.70	3.38	4.32	3.44	2.72	2.62	2.66	2.92
9	3.94	3.46	5.05	3.37	3.65	4.20	3.85	3.16	2.80	2.62	2.66	2.95
10	3.82	5.14	5.33	3.34	4.90	3.81	3.62	3.02	3.59	2.60	2.72	2.70
11	3.69	4.88	5.10	3.29	5.00	3.64	3.39	2.94	3.15	3.17	2.66	2.84
12	3.62	4.35	4.68	3.24	4.49	3.51	3.26	2.88	2.95	3.60	2.66	2.78
13	3.50	4.11	4.40	3.44	4.19	3.61	3.21	2.86	2.82	3.16	2.65	2.85
14	3.42	3.94	4.29	4.44	3.96	4.10	3.40	2.93	2.76	2.98	2.66	3.54
15	3.52	3.78	4.10	4.08	3.82	3.64	3.20	3.26	2.70	2.98	2.64	3.32
16	4.25	4.19	4.00	3.84	3.68	3.74	3.10	3.35	3.40	3.05	2.60	3.24
17	5.08	4.38	3.89	3.71	3.57	4.08	3.15	3.58	3.80	3.00	2.64	3.04
18	4.66	4.14	3.74	3.60	3.46	3.72	3.04	3.60	3.50	2.90	2.62	3.00
19	4.54	4.02	3.66	3.52	3.39	3.48	2.96	3.32	3.25	2.88	2.62	2.96
20	4.44	4.20	3.58	3.50	3.36	3.34	2.92	3.16	3.08	2.86	2.61	2.84
21	4.32	4.08	3.80	3.58	3.70	3.24	2.87	3.06	3.00	2.84	2.61	2.80
22	4.18	4.03	4.26	3.65	4.09	3.18	2.84	2.95	2.94	2.80	2.61	2.83
23	4.05	4.02	4.10	3.88	3.88	3.14	2.84	2.88	2.84	2.78	2.58	2.76
24	3.98	4.10	3.99	3.82	3.69	3.12	3.12	2.79	3.05	2.82	2.68	2.73
25	3.86	4.46	5.02	3.72	3.58	3.16	2.92	2.76	3.01	2.81	2.64	2.80
26	3.76	4.38	5.24	3.68	3.83	3.08	2.84	2.76	2.88	2.78	2.62	2.80
27	3.72	4.26	4.75	3.60	4.94	3.04	2.83	2.72	2.82	2.76	2.60	2.76
28	3.66	4.08	5.44	3.59	4.47	3.08	2.86	2.72	2.78	2.76	2.60	2.82
29	3.59	......	5.34	3.48	4.13	3.22	2.92	2.72	2.76	2.74	2.60	2.74
30	3.54	......	4.84	4.46	3.88	3.24	2.84	2.70	2.73	2.73	2.58	2.70
31	3.28	......	4.44	......	3.71	......	2.89	2.66	......	2.71	......	2.76
1910												
1	2.74	3.38	4.06	2.96	3.66	3.25	3.19	2.75	2.64	2.55	2.47	2.78
2	2.85	3.18	4.14	2.94	3.53	3.18	3.11	2.71	2.70	2.53	2.47	2.66
3	3.70	3.52	4.06	3.00	3.46	3.12	3.12	2.72	2.78	2.51	2.46	2.64
4	3.65	4.06	3.92	3.12	3.48	3.06	3.06	2.71	2.80	2.51	2.46	2.71
5	3.46	3.92	3.80	3.16	3.42	3.36	3.11	2.98	2.70	2.47	2.44	2.71

Daily gage height, in feet, of Wolf Creek near Narrows, Va., for 1908–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910												
6	3.36	3.80	3.95	3.08	3.35	4.40	3.38	2.86	2.72	2.45	2.44	2.98
7	5.05	3.44	4.14	3.04	3.82	4.08	3.32	2.76	2.78	2.55	2.44	3.32
8	4.35	3.54	4.02	3.02	3.50	3.81	3.82	2.76	2.67	2.63	2.43	2.98
9	3.86	3.49	3.86	2.98	3.46	3.61	3.35	2.94	2.69	2.63	2.43	2.92
10	3.59	3.56	3.74	2.96	3.48	3.62	3.24	2.76	2.70	2.59	2.42	2.89
11	3.40	3.42	3.71	2.92	3.44	3.90	3.18	2.74	2.73	2.55	2.44	2.90
12	3.34	3.31	3.62	2.96	3.42	4.42	3.14	2.70	2.73	2.51	2.44	2.88
13	3.30	3.34	3.58	3.38	3.56	5.08	3.03	2.68	2.71	2.50	2.44	2.87
14	3.28	3.28	3.54	3.62	3.54	5.35	3.10	2.66	2.63	2.47	2.44	2.72
15	3.21	3.33	3.48	3.50	3.48	4.75	3.04	2.64	2.59	2.47	2.42	2.74
16	3.12	3.52	3.40	3.42	3.40	4.62	3.00	2.64	2.60	2.48	2.46	2.76
17	3.12	4.38	3.32	3.52	3.36	5.40	3.08	2.66	2.56	2.48	2.45	2.66
18	3.35	4.98	3.30	3.82	3.43	4.75	3.42	2.60	2.51	2.43	2.44	2.60
19	4.36	4.40	3.28	3.74	3.46	4.28	3.50	2.65	2.54	2.44	2.44	2.76
20	4.02	4.10	3.26	3.72	3.88	4.06	3.32	2.67	2.53	2.50	2.46	2.80
21	5.35	3.96	3.26	3.68	3.36	3.88	3.18	2.66	2.53	2.48	2.48	2.66
22	5.20	3.90	3.22	3.80	3.30	4.22	3.07	2.60	2.51	2.54	2.46	2.60
23	4.45	3.78	3.18	3.75	3.24	4.25	3.00	2.60	2.51	2.54	2.45	2.78
24	4.04	3.68	3.11	4.04	3.20	3.94	3.02	2.58	2.50	2.54	2.44	3.14
25	3.83	3.56	3.08	4.22	4.04	3.98	2.90	2.58	2.49	2.50	2.46	3.42
26	3.72	3.48	3.06	4.20	4.20	3.88	2.85	2.63	2.55	2.52	2.44	3.22
27	3.62	3.42	3.05	4.10	3.81	3.62	2.81	2.62	2.53	2.47	2.48	3.12
28	3.66	3.44	3.02	4.02	3.64	3.48	2.80	2.62	2.57	2.44	2.60	3.06
29	3.62	....	3.01	3.90	3.49	3.36	2.78	2.62	2.63	2.46	3.18	3.02
30	3.44	....	3.00	3.78	3.42	3.28	2.76	2.60	2.57	2.52	3.00	3.70
31	3.52	....	2.98	....	3.28	....	2.80	2.60	....	2.49	....	4.10
1911												
1	3.78	4.65	3.19	3.69	3.48	2.88	2.74	2.44	2.64	2.48	2.89	3.04
2	5.40	4.28	3.17	3.63	3.40	2.84	2.62	2.45	2.62	3.18	2.84	3.02
3	5.58	4.02	3.13	3.68	3.31	2.75	2.62	2.45	2.56	4.86	2.80	3.00
4	5.05	4.94	3.08	5.14	3.25	2.70	2.68	2.48	2.52	3.72	2.79	3.00
5	4.26	3.83	3.08	5.67	3.22	2.70	2.69	2.64	2.54	3.36	2.78	2.94
6	3.92	3.68	3.79	5.60	3.20	2.70	2.65	2.66	2.59	3.08	2.86	2.90
7	3.62	3.60	4.96	5.02	3.18	2.72	2.62	2.54	2.63	3.04	3.29	2.90
8	3.52	3.76	4.86	5.00	3.15	2.69	2.64	2.58	2.63	3.03	3.28	2.88
9	3.41	5.35	4.70	5.10	3.13	2.64	2.68	2.56	2.58	3.00	3.22	2.86
10	3.28	5.90	6.52	4.86	3.12	2.62	2.92	2.50	2.52	2.96	3.20	2.81
11	3.15	4.95	5.30	4.48	3.09	2.60	2.86	2.46	2.51	3.34	3.18	2.80
12	3.10	4.40	4.66	4.31	3.06	2.60	2.83	2.44	2.66	3.38	3.16	2.80
13	3.09	4.04	4.32	4.15	3.01	2.60	2.86	2.60	2.68	3.22	3.38	2.79
14	3.04	3.88	4.32	4.02	3.00	2.60	2.75	2.79	2.60	3.12	3.87	2.80
15	3.01	3.70	4.10	4.30	2.98	2.56	2.71	2.64	2.56	3.08	3.34	2.80
16	2.95	3.56	3.95	4.61	2.96	2.59	2.66	2.58	2.54	3.00	3.26	2.86
17	2.95	3.42	3.80	4.40	2.98	2.58	2.62	2.54	2.61	3.12	3.18	2.92
18	2.99	3.36	3.71	4.16	2.92	2.61	2.59	2.56	2.60	6.88	3.32	2.91
19	2.96	3.37	3.65	4.03	2.91	2.66	2.56	2.66	2.56	4.68	3.82	2.87
20	2.94	3.60	3.82	4.28	2.89	3.16	2.51	2.55	2.54	4.06	3.66	2.84
21	2.99	3.63	3.75	4.53	2.86	2.81	2.53	2.54	2.54	3.72	3.52	2.84
22	3.31	3.51	3.72	4.39	2.82	2.70	2.51	2.50	2.60	3.51	3.38	2.92
23	3.78	3.52	3.72	4.16	2.80	2.62	2.50	2.44	2.97	3.46	3.28	4.68
24	3.70	3.42	3.54	3.95	2.88	2.58	2.48	2.45	2.78	3.33	3.20	4.19
25	3.56	3.38	3.44	3.80	2.79	2.74	2.47	2.44	2.08	3.22	3.28	4.32
26	3.49	3.34	3.41	3.68	2.74	2.72	2.46	2.50	2.62	3.13	3.20	4.16
27	3.60	3.29	3.98	3.59	2.76	2.66	2.46	2.48	2.59	3.08	3.16	4.19
28	3.62	3.23	3.98	3.49	2.71	3.16	2.45	2.54	2.58	3.04	3.18	4.04
29	3.68	....	3.92	3.43	2.69	3.06	2.44	2.50	2.54	2.99	3.16	3.82
30	5.85	....	3.87	3.41	2.64	2.85	2.46	2.58	2.51	2.96	3.12	3.71
31	5.40	....	3.76	....	2.70	....	2.46	2.64	....	2.92	....	3.72

Daily gage height, in feet, of Wolf Creek near Narrows, Va., for 1908–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912												
1	3.65	4.35	3.95	4.7	4.6	2.99	4.4	3.24	3.01	2.82	2.68	2.75
2	3.6	4.05	3.7	6.1	4.3	2.95	4.05	3.16	2.94	2.73	2.68	2.70
3	3.55	3.7	3.7	6.8	4.1	2.94	3.7	3.06	2.88	2.69	2.68	2.69
4	3.49	3.6	3.55	5.4	3.9	2.92	3.8	3.06	2.88	2.68	2.66	2.80
5	3.27	3.42	3.55	4.8	3.75	2.96	5.0	3.00	2.84	2.66	2.61	3.02
6	3.24	3.40	3.5	4.4	3.65	2.90	4.7	2.93	2.80	2.64	2.62	3.25
7	3.28	3.30	3.45	4.25	3.7	2.86	4.0	2.86	2.83	2.64	2.98	3.36
8	3.12	3.35	3.85	4.1	3.6	2.82	3.8	2.88	2.81	2.61	3.75	3.31
9	3.16	3.22	5.2	3.9	3.5	2.78	3.7	2.84	2.76	2.60	3.45	3.20
10	3.09	3.18	5.0	3.8	3.42	2.76	3.7	2.82	2.71	2.60	3.24	3.11
11	3.10	3.14	4.5	3.7	3.38	2.73	3.55	2.84	2.68	2.74	3.12	3.06
12	3.12	3.04	4.6	3.6	3.7	2.71	3.55	2.80	2.68	2.58	3.01	3.01
13	3.09	3.11	7.3	3.55	3.65	2.70	3.31	2.82	2.65	2.58	3.00	2.90
14	3.03	3.08	6.4	3.5	3.55	2.69	3.20	2.88	2.64	2.67	3.00	2.84
15	3.04	3.10	7.5	3.42	3.55	2.72	3.20	2.84	2.62	2.84	2.96	2.83
16	3.06	3.06	7.4	3.47	5.5	2.77	3.09	2.77	2.62	2.76	2.89	2.88
17	3.02	3.08	5.8	3.48	5.6	2.77	3.00	2.72	2.62	2.70	2.86	2.83
18	2.98	3.18	5.0	3.5	4.7	2.78	2.96	2.74	2.70	2.66	2.82	2.84
19	3.24	3.22	4.6	3.48	4.25	2.93	3.02	2.33	2.70	2.69	2.78	2.84
20	4.3	3.35	4.35	3.42	4.0	2.86	2.98	3.16	2.70	2.79	2.76	2.79
21	3.9	4.8	4.15	3.42	3.75	2.78	2.93	3.7	2.66	2.86	2.72	2.78
22	3.7	6.4	4.1	3.42	3.6	2.72	2.92	3.55	2.69	2.72	2.72	2.76
23	3.6	4.8	3.95	3.6	3.48	2.75	3.10	3.48	2.94	2.76	2.70	2.72
24	3.55	4.4	4.2	3.5	3.39	3.08	3.06	3.38	3.39	2.79	2.74	2.74
25	3.5	4.3	4.8	3.48	3.42	6.2	3.30	3.24	3.11	2.80	2.70	2.66
26	3.5	4.3	4.7	3.43	3.32	4.15	3.55	3.18	2.96	2.78	2.69	2.78
27	4.1	4.8	4.45	4.6	3.20	4.45	3.24	3.46	3.24	2.74	2.69	2.90
28	3.95	4.5	4.25	5.3	3.16	4.3	3.10	3.26	3.05	2.70	2.72	2.86
29	4.0	4.2	7.8	4.8	3.17	4.5	3.02	3.16	2.94	2.69	2.70	2.90
30	4.8	....	6.4	4.9	3.12	3.95	3.37	3.08	2.84	2.68	2.68	3.08
31	4.8	....	5.0	....	3.06	....	3.30	3.08	....	2.67	....	4.62
1913												
1	3.95	4.1	4.4	4.1	3.19	3.9	2.90	2.55	2.61	2.51	2.68	2.78
2	3.6	3.95	4.1	3.9	3.14	3.65	2.88	2.54	2.52	2.50	2.62	3.8
3	3.6	3.9	3.9	3.75	3.10	3.45	2.86	2.51	2.50	2.50	2.58	3.48
4	3.65	4.05	3.7	3.6	3.09	3.48	2.89	2.49	2.48	2.47	2.56	3.34
5	3.55	4.0	3.6	3.5	3.01	3.35	3.44	2.48	2.46	2.45	2.58	3.20
3	3.14	3.9	3.49	3.42	3.00	3.22	3.08	2.54	2.45	2.46	2.59	3.12
7	3.85	3.7	3.39	3.34	3.00	3.19	2.92	2.66	2.44	2.46	2.58	3.08
8	3.85	3.6	3.28	3.30	3.02	3.7	2.80	2.58	2.46	2.44	2.60	3.10
9	4.35	3.48	3.25	3.26	3.00	3.7	2.74	2.58	2.46	2.48	3.23	3.02
10	4.05	3.40	3.25	3.20	2.98	3.48	2.71	2.54	2.46	2.46	3.41	2.92
11	3.9	3.42	3.38	3.27	2.94	3.36	2.72	2.58	2.42	2.46	3.13	3.02
12	4.15	3.6	3.44	4.2	2.90	3.45	3.29	2.70	2.40	2.44	3.00	2.90
13	4.8	3.45	3.42	5.2	2.88	3.38	2.95	2.67	2.43	2.41	3.00	2.92
14	4.3	3.35	4.6	4.7	2.88	3.29	2.85	2.66	2.38	2.41	3.26	2.88
15	4.0	3.28	5.8	4.35	3.02	3.14	2.79	2.66	2.34	2.40	3.36	2.86
16	3.8	3.28	5.8	4.3	2.90	3.04	2.80	2.63	2.40	2.40	3.31	2.86
17	3.65	3.32	4.8	3.7	2.94	3.11	2.72	2.56	2.46	2.38	3.9	2.80
18	3.6	3.27	4.3	4.0	2.99	3.08	2.74	2.51	2.54	2.40	3.85	2.78
19	3.48	3.19	4.1	3.9	2.90	3.25	2.82	2.48	2.62	2.44	3.5	2.76
20	3.38	3.20	3.9	3.75	2.84	3.15	2.78	2.64	2.52	2.76	3.32	2.73
21	3.39	3.25	3.8	3.55	2.93	3.00	2.70	2.64	2.76	2.90	3.18	2.71
22	3.7	3.24	3.75	3.46	3.00	2.91	2.65	2.60	3.07	2.76	3.07	2.70
23	3.6	3.20	3.55	3.40	3.32	3.15	2.59	2.62	2.86	2.68	3.02	2.71
24	3.75	3.22	3.48	3.36	5.2	3.35	2.62	2.72	2.74	2.68	2.97	2.70
25	4.05	3.22	3.46	3.29	4.3	3.30	2.70	2.63	2.62	3.26	2.92	2.72

Daily gage height, in feet, of Wolf Creek near Narrows, Va., for 1908–1914—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1913												
26	4.15	3.18	3.5	3.25	3.9	3.12	2.66	2.56	2.52	3.22	2.84	3.09
27	4.35	3.85	10.2	3.35	4.6	3.04	2.64	2.50	2.57	3.04	2.78	3.16
28	4.8	4.8	7.0	3.29	5.4	3.28	2.61	2.46	2.48	2.97	2.74	3.05
29	4.35	....	5.4	3.30	4.6	3.04	2.66	2.44	2.48	2.90	2.70	3.12
30	4.1	....	4.8	3.27	4.15	2.94	2.62	2.74	2.49	2.81	2.69	3.11
31	4.0	....	4.4	....	4.45	....	2.58	2.76	....	2.75	....	3.16
1914												
1	3.24	4.25	3.9	6.0	3.26	2.57	2.36	2.34	2.62	2.25	2.38	2.96
2	3.22	3.9	3.9	5.9	3.19	2.54	2.40	2.33	2.56	2.21	2.35	3.85
3	3.95	3.8	3.7	5.2	3.15	2.48	2.40	2.34	2.47	2.20	2.36	4.35
4	3.7	3.7	3.7	4.6	3.12	2.47	2.40	2.32	2.40	2.24	2.35	3.9
5	3.20	3.65	3.7	4.3	3.17	2.50	2.39	2.34	2.38	2.31	2.36	6.2
6	3.19	3.7	3.8	4.05	3.20	2.53	2.39	2.34	2.37	2.32	2.34	4.8
7	3.16	5.0	3.7	3.85	3.18	2.58	2.38	2.34	2.34	2.30	2.36	4.25
8	3.16	4.8	3.65	3.85	3.12	2.57	2.34	2.33	2.32	2.31	2.35	3.95
9	3.7	4.35	3.6	3.8	3.14	2.50	2.34	2.42	2.32	2.26	2.37	3.7
10	5.2	4.1	3.46	3.7	3.13	2.52	2.36	2.42	2.31	2.25	2.33	3.5
11	4.5	3.95	4.7	3.6	3.08	2.47	2.46	2.46	2.34	2.22	2.34	3.40
12	4.05	3.7	5.6	3.55	3.04	2.46	2.46	2.48	2.45	2.21	2.36	3.29
13	3.6	3.6	5.0	3.5	3.02	2.60	2.42	2.42	2.48	2.21	2.35	3.21
14	3.5	3.40	4.6	3.41	3.00	2.74	3.12	2.30	2.42	2.32	2.36	3.18
15	3.48	3.49	4.5	3.6	2.98	2.56	3.12	2.32	2.35	2.48	2.42	2.92
16	3.40	3.42	4.8	4.4	2.94	2.49	2.68	2.30	2.31	2.94	2.63	2.85
17	3.37	3.31	5.3	4.45	2.88	2.48	2.62	2.29	2.29	3.05	2.73	3.05
18	3.31	3.6	5.4	4.2	2.85	2.44	2.64	2.26	2.27	2.78	2.71	3.00
19	3.25	4.9	5.1	4.0	2.84	2.44	2.60	2.24	2.26	2.76	2.67	2.95
20	3.29	6.5	4.35	4.3	2.83	2.45	2.58	2.21	2.24	2.70	2.62	3.35
21	4.25	5.4	4.0	4.4	2.81	2.70	2.48	2.18	2.26	2.62	2.42	4.05
22	4.05	4.8	3.95	4.2	2.79	2.67	2.41	2.19	2.24	2.54	2.54	4.6
23	3.75	4.3	3.75	4.05	2.75	2.54	2.38	2.23	2.24	2.49	2.56	4.1
24	3.6	4.7	3.8	3.9	2.71	2.48	2.34	2.22	2.28	2.50	2.45	3.85
25	5.1	4.4	3.9	3.75	2.68	2.48	2.32	2.31	2.35	2.44	2.49	4.0
26	4.6	4.15	4.05	3.7	2.65	2.47	2.38	2.65	2.38	2.38	2.50	3.8
27	4.2	4.05	4.3	3.6	2.64	2.44	2.42	2.86	2.40	2.40	2.48	3.40
28	3.9	3.95	4.15	3.48	2.60	2.41	2.46	3.8	2.32	2.48	2.51	3.41
29	3.8	....	4.05	3.38	2.59	2.40	2.44	3.38	2.29	2.45	2.50	3.55
30	3.6	....	4.9	3.33	2.60	2.38	2.39	2.92	2.28	2.45	2.56	5.1
31	3.9	....	5.8	....	2.60	....	2.35	2.73	....	2.42	....	4.9

NOTE.—No ice near station except in extremely cold weather; discharge relation probably not seriously affected thereby.

TENNESSEE RIVER BASIN.

SOUTH FORK OF HOLSTON RIVER NEAR CHILHOWIE, VA.

Location.—At Cole's footbridge just above mouth of Goose Creek, 2 miles below St. Clair Creek, and 4½ miles south of Chilhowie.

Drainage area.—108 square miles.

Records available.—June 10, 1907, to December 31, 1909.

Gage.—Vertical staff spiked to an oak tree on left bank about 100 feet below bridge; read once daily.

Discharge measurements.—Made from footbridge.

Channel and control.—No information on channel. Plotting of discharge measurements indicates that control changes slightly.

Extremes of discharge.—Maximum stage observed: 4.4 feet, June 11, 1907; discharge not computed. Minimum stage observed: 0.4 foot, September to December, 1909; discharge, 40 second-feet.

Winter flow.—No information. Discharge relation probably not affected by ice.

Regulation.—Operation of mills above station probably has some influence on flow, especially at low stages.

Accuracy.—Records good except at extremely high and low stages.

Coöperation.—Station maintained by United States Geological Survey in coöperation with United States Forest Service.

Discharge measurements of South Fork of Holston River near Chilhowie, Va., in 1907–1909.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1907				1908			
June 10	W. E. Hall	1.40	385	July 7	F. P. Thomas	1.05	198
Aug. 13	B. M. Hall, Jr.	.68	97	July 7	W. E. Hall	1.08	187
Sept. 9	do	.57	68				
1908				1909			
				Mar. 20	W. A. Lamb	1.06	188
Feb. 21	W. E. Hall	1.07	187	Sept. 23	E. H. Swett	.49	51
July 7	F. P. Thomas	1.08	199	Sept. 23	do	.40	40

Daily gage height, in feet, of South Fork of Holston River near Chilhowie, Va., for 1907–1909.

[P. Cole, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	......	0.8	0.9	0.6	0.8	0.6	0.8
2	......	......	......	......	......	......	.7	.8	.6	.7	.5	.9
3	......	......	......	......	......	......	.9	.8	.6	.7	.8	.8
4	......	......	......	......	......	......	.7	.7	.6	.7	.8	.8
5	......	......	......	......	......	......	.7	.7	.6	.9	.7	.7
6	......	......	......	......	......	......	.7	.7	.6	.8	.7	.7
7	......	......	......	......	......	......	.7	.7	.6	.8	.7	.7
8	......	......	......	......	......	......	.6	.7	.6	.7	.6	.6
9	......	......	......	......	......	......	.6	.6	.5	.7	.6	.7
10	......	......	......	......	......	1.4	.8	.8	.5	.7	.9	.8
11	......	......	......	......	......	4.4	.8	.7	.6	.7	1.3	.9
12	......	......	......	......	......	2.6	.7	.7	.6	.6	1.1	.9
13	......	......	......	......	......	3.0	1.4	.7	.6	.6	1.0	.9
14	......	......	......	......	......	4.1	1.1	.6	.5	.6	.9	1.0
15	......	......	......	......	......	2.6	.9	.6	.5	.6	.8	1.3
16	......	......	......	......	......	1.9	1.0	.6	.5	.6	.8	1.3
17	......	......	......	......	......	1.6	.9	.8	.5	.6	.7	1.2
18	......	......	......	......	......	1.4	.8	.8	.7	.6	.8	1.1
19	......	......	......	......	......	1.3	1.0	.7	.7	.6	.9	1.0
20	......	......	......	......	......	1.2	.9	.7	.7	.5	1.0	.9
21	......	......	......	......	......	1.1	.8	.6	.6	.5	1.0	.9
22	......	......	......	......	......	1.1	.7	.6	.8	.5	1.0	.8
23	......	......	......	......	......	1.0	.8	.6	2.3	.5	1.0	1.0
24	......	......	......	......	......	1.0	.7	.8	2.1	.5	1.4	1.5
25	......	......	......	......	......	1.0	.7	.7	1.5	.5	1.5	1.3
26	......	......	......	......	......	.9	.7	.7	1.2	.5	1.3	1.1
27	......	......	......	......	......	.9	.7	.6	1.0	.5	1.1	1.0
28	......	......	......	......	......	.8	.6	.6	.9	.6	1.0	1.0
29	......	......	......	......	......	.9	.6	.6	.9	.6	1.0	.9
30	......	......	......	......	......	.8	1.3	.6	.8	.5	.9	1.2
31	......	......	......	......	......	......	1.0	.9	......	.5	......	1.6
1908												
1	1.4	0.9	1.1	1.3	0.9	.8	1.2	.6	.6	.4	1.1	.9
2	1.2	.9	1.6	2.5	.9	.8	.9	.5	.6	.4	1.0	1.2
3	1.1	.8	1.5	2.6	.9	.8	.8	.5	.6	.4	.9	1.1
4	1.0	.8	1.4	1.9	.8	1.2	.8	.6	.6	.4	.8	1.0
5	1.3	.9	1.3	1.6	.8	1.9	1.2	.5	.5	.4	.8	.9
6	1.3	1.0	2.1	1.4	.8	1.4	1.2	.6	.6	.4	.7	.9
7	1.2	1.0	1.8	1.3	1.1	1.1	1.1	.6	.6	.4	.7	1.4
8	1.1	.9	1.5	1.2	1.5	1.0	1.0	.6	.5	.4	.7	2.1
9	1.0	.9	1.3	1.1	1.3	.9	1.0	.8	.6	.4	.6	1.5
10	1.0	.9	1.2	1.0	1.2	.9	.9	.7	.5	.6	.6	1.3
11	.9	.9	1.1	1.0	1.1	.8	.8	.6	.5	.6	.7	1.1
12	4.0	1.1	1.2	1.0	1.0	.8	.8	.6	.5	.5	.8	1.3
13	2.4	1.8	1.1	.9	1.0	.8	.7	.6	.5	.5	.8	1.3
14	1.8	2.2	1.1	.9	.9	.7	1.0	.6	.5	.4	.8	1.2
15	1.6	2.5	1.1	.9	.9	1.1	.8	.5	.5	.4	.8	1.1
16	1.4	2.1	1.1	.9	.8	.9	.8	.5	.5	.4	.7	1.0
17	1.3	1.7	1.0	.9	.8	.8	.7	.5	.4	.4	.7	1.0
18	1.2	1.4	1.0	.8	.8	.8	.7	.5	.4	.4	.8	.9
19	1.1	1.3	1.0	.8	.8	.7	.8	.6	.4	.4	.9	.9
20	1.1	1.2	1.0	.8	.9	.7	.7	.6	.4	.4	.9	.9
21	1.0	1.1	1.1	.8	.8	.7	.6	.5	.5	.4	.9	.9
22	1.0	1.1	1.2	.8	.8	.7	.9	.6	.4	.4	.8	1.0
23	1.1	1.0	1.3	.8	.8	1.2	.7	.8	.4	.4	.8	1.1
24	1.0	1.0	1.4	.7	.8	1.0	.7	.7	.4	.8	.7	1.0
25	1.0	.9	1.4	.9	.9	.9	.6	.6	.4	.7	.7	1.1

Daily gage height, in feet, of South Fork of Holston River near Chilhowie, Va., for 1907–1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
26	1.0	1.0	1.8	1.4	.8	.8	.6	.9	.4	.6	.7	1.6
27	1.1	1.0	1.2	1.2	1.0	.7	.7	.9	.4	.6	.7	1.4
28	1.0	.9	1.1	1.1	1.0	.7	.6	.8	.4	.6	.6	1.3
29	1.0	.9	1.0	1.0	.9	.7	.6	.7	.4	.9	.6	1.3
30	.9	......	1.0	.9	1.1	.7	.7	.7	.4	1.4	.7	1.6
31	.9	......	.9	......	.9	......	.6	.7	......	1.5	......	1.8
1909												
1	1.7	0.8	1.1	1.3	1.8	0.7	0.8	0.6	0.5	0.4	0.4	0.4
2	1.5	.8	1.1	1.2	1.8	.7	.8	.7	.4	.4	.4	.4
3	1.3	.8	1.0	1.2	1.5	.8	.7	.6	.5	.4	.4	.4
4	1.2	.8	1.1	1.1	1.3	1.1	.7	.6	.5	.4	.4	.4
5	1.4	.8	1.0	1.0	1.2	1.3	.7	.6	.4	.4	.4	.4
6	1.7	.9	1.1	1.0	1.1	1.1	.7	.5	.4	.4	.4	.4
7	1.5	.8	1.6	1.0	1.0	.9	.9	.6	.5	.4	.4	.4
8	1.3	.9	1.4	.9	.9	.8	1.5	.6	.4	.4	.4	.5
9	1.2	.9	1.8	.9	.9	1.0	1.2	.6	.5	.4	.4	.5
10	1.1	2.4	1.4	.9	1.2	1.1	1.0	.5	.4	.4	.4	.4
11	1.0	1.9	1.4	.9	1.3	1.0	.9	.5	.5	.5	.4	.4
12	1.0	1.5	1.8	.8	1.2	.9	.8	.5	.4	.8	.4	.4
13	.9	1.3	1.2	.8	1.1	.9	.9	.5	.4	.4	.4	.5
14	.9	1.2	1.4	1.2	1.0	.9	1.3	.5	.4	.4	.4	.7
15	.9	1.1	1.5	1.2	.9	.8	1.1	.6	.4	.6	.4	.6
16	.9	1.3	1.4	1.1	.9	1.2	.9	.7	.6	.6	.4	.6
17	1.3	1.3	1.3	1.0	.9	1.0	.9	.7	.5	.5	.4	.5
18	1.3	1.2	1.2	.9	.8	1.1	.8	.8	.4	.5	.4	.5
19	1.2	1.2	1.1	.9	.8	1.0	.8	.7	.4	.5	.4	.4
20	1.2	1.2	1.0	.9	.8	.9	.7	.6	.4	.5	.4	.4
21	1.1	1.2	1.2	.9	1.2	.8	.7	.6	.4	.5	.4	.4
22	1.0	1.2	1.0	.9	1.5	.8	.7	.5	.4	.5	.4	.4
23	1.0	1.3	1.0	.9	1.2	.7	.7	.5	.4	.4	.4	.4
24	.9	1.4	1.0	.9	1.1	.8	.6	.5	.5	.5	.4	.4
25	.9	1.6	1.2	.9	1.0	.7	.6	.5	.5	.5	.4	.4
26	1.0	1.4	1.5	.9	.9	.7	.6	.5	.4	.5	.4	.4
27	1.1	1.3	1.4	.8	.9	.7	.6	.5	.4	.5	.4	.4
28	1.1	1.2	2.1	.9	.8	.8	.6	.5	.4	.5	.4	.4
29	1.0	......	2.1	.8	.8	.8	.6	.5	.4	.5	.4	.4
30	1.0	......	1.7	.8	.7	.8	.7	.5	.4	.4	.4	.4
31	.9	......	1.5	......	.7	......	.6	.5	......	.4	......	.4

Daily discharge, in second-feet, of South Fork of Holston River near Chilhowie, Va., for 1907–1909.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	......	119	145	79	119	79	119
2	......	......	......	......	......	......	97	119	79	97	65	145
3	......	......	......	......	......	......	145	119	79	97	119	119
4	......	......	......	......	......	......	97	97	79	97	119	119
5	......	......	......	......	......	......	97	97	79	145	97	97
6	......	......	......	......	......	......	97	97	79	119	97	97
7	......	......	......	......	......	......	97	97	79	119	97	97
8	......	......	......	......	......	......	79	97	79	97	79	79
9	......	......	......	......	......	......	79	79	65	97	79	97
10	......	......	......	......	......	360	119	119	65	97	145	119

Daily discharge, in second-feet, of South Fork of Holston River near Chilhowie, Va., for 1907–1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
11	....	....	....	....	....	....	119	97	79	97	300	145
12	....	....	....	....	....	....	97	97	79	79	210	145
13	....	....	....	....	....	....	360	97	79	79	175	145
14	....	....	....	....	....	....	210	79	65	79	145	175
15	....	....	....	....	....	....	145	79	65	79	119	300
16	....	....	....	....	....	760	175	70	65	79	119	300
17	....	....	....	....	....	505	145	119	65	79	97	250
18	....	....	....	....	....	360	119	119	97	79	119	210
19	....	....	....	....	....	300	175	97	97	79	145	175
20	....	....	....	....	....	250	145	97	97	65	175	145
21	....	....	....	....	....	210	119	79	79	65	175	145
22	....	....	....	....	....	210	97	79	119	65	175	119
23	....	....	....	....	....	175	119	79	....	65	175	175
24	....	....	....	....	....	175	97	119	....	65	360	430
25	....	....	....	....	....	175	97	97	430	65	430	300
26	....	....	....	....	....	145	97	97	250	65	300	210
27	....	....	....	....	....	145	97	79	175	65	210	175
28	....	....	....	....	....	119	79	79	145	79	175	175
29	....	....	....	....	....	145	79	79	145	79	175	145
30	....	....	....	....	....	119	300	79	119	65	145	250
31	....	....	....	....	....	....	175	145	....	65	....	505
1908												
1	360	145	210	300	145	119	250	79	79	55	210	145
2	250	145	505	....	145	119	145	65	79	55	175	250
3	210	119	430	....	145	119	119	65	79	55	145	210
4	175	119	360	760	119	250	119	79	79	55	119	175
5	300	145	300	505	119	760	250	65	65	55	119	145
6	300	175	....	360	119	360	250	79	79	55	97	145
7	250	175	670	300	210	210	210	79	79	55	97	360
8	210	145	430	250	430	175	175	79	65	55	97	....
9	175	145	300	210	300	145	175	119	79	55	79	430
10	175	145	250	175	250	145	145	97	65	79	79	300
11	145	145	210	175	210	119	119	79	65	79	97	210
12	....	210	250	175	175	119	119	79	65	65	119	300
13	....	670	210	145	175	119	97	79	65	65	119	300
14	670	....	210	145	145	97	175	79	65	55	119	250
15	505	....	210	145	145	210	119	65	65	55	119	210
16	360	....	210	145	119	145	119	65	65	55	97	175
17	300	585	175	145	119	119	97	65	55	55	97	175
18	250	360	175	119	119	119	97	65	55	55	119	145
19	210	300	175	119	119	97	119	79	55	55	145	145
20	210	250	175	119	145	97	97	79	55	55	145	145
21	175	210	210	119	119	97	79	65	65	55	145	145
22	175	210	250	119	119	97	145	79	55	55	119	175
23	210	175	300	119	119	250	97	119	55	55	119	210
24	175	175	360	97	119	175	97	97	55	119	97	175
25	175	145	360	145	145	145	79	79	55	97	97	210
26	175	175	300	360	119	119	79	145	55	79	97	505
27	210	175	250	250	175	97	97	145	55	79	97	360
28	175	145	210	210	175	97	79	119	55	79	79	300
29	175	145	175	175	145	97	79	97	55	145	79	300
30	145	....	175	145	210	97	97	97	55	360	97	505
31	145	....	145	....	145	....	79	97	....	430	....	670
1909												
1	585	120	210	300	670	95	120	75	55	40	40	40
2	430	120	210	250	670	95	120	95	40	40	40	40
3	300	120	175	250	430	120	95	75	55	40	40	40
4	250	120	210	210	300	210	95	75	55	40	40	40
5	360	120	175	175	250	300	95	75	40	40	40	40

Daily discharge, in second-feet, of South Fork of Holston River near Chilhowie, Va., for 1907–1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
6	585	145	210	175	210	210	95	55	40	40	40	40
7	430	120	505	175	175	145	145	75	55	40	40	40
8	300	145	360	145	145	120	430	75	40	40	40	55
9	250	145	300	145	145	175	250	75	55	40	40	55
10	210	1,260	360	145	250	210	175	55	40	40	40	40
11	175	760	360	145	300	175	145	55	55	55	40	40
12	175	430	300	120	250	145	120	55	40	120	40	40
13	145	300	250	120	210	145	145	55	40	40	40	55
14	145	250	360	250	175	145	300	55	40	40	40	95
15	145	210	430	250	145	120	210	75	40	75	40	75
16	145	300	360	210	145	250	145	95	75	75	40	75
17	300	300	300	175	145	175	145	95	55	55	40	55
18	300	250	250	145	120	210	120	120	40	55	40	55
19	250	250	210	145	120	175	120	95	40	55	40	40
20	250	250	175	145	120	145	95	75	40	55	40	40
21	210	250	250	145	250	120	95	75	40	55	40	40
22	175	250	175	145	430	120	95	55	40	55	40	40
23	175	300	175	145	250	95	95	55	40	40	40	40
24	145	360	175	145	210	120	75	55	55	55	40	40
25	145	505	250	145	175	95	75	55	55	55	40	40
26	175	360	430	145	145	95	75	55	40	55	40	40
27	210	300	360	120	145	95	75	55	40	55	40	40
28	210	250	945	145	120	120	75	55	40	55	40	40
29	175	....	945	120	120	120	75	55	40	55	40	40
30	175	....	585	120	95	120	95	55	40	40	40	40
31	145	....	430	....	95	....	75	55	....	40	....	40

NOTE.—Discharge for 1907 and 1908 determined from a rating curve fairly well defined between 50 and 500 second-feet; after June 10, 1907, on days for which estimates are missing, discharge was greater than 900 second-feet. Discharge for 1909 determined from the same rating curve slightly revised below 145 second-feet and extended to 1,260 second-feet.

Monthly discharge of South Fork of Holston River near Chilhowie, Va., for 1909.

[Drainage area, 108 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
January	585	145	247	2.29	2.64	A.
February	1,260	120	296	2.74	2.85	A.
March	945	175	336	3.11	3.58	A.
April	300	120	168	1.56	1.74	A.
May	670	95	226	2.09	2.41	A.
June	300	95	149	1.38	1.54	A.
July	430	75	131	1.21	1.40	A.
August	120	55	68.7	.636	.73	B.
September	75	40	45.7	.423	.47	C.
October	120	40	51.1	.473	.55	C.
November	40	40	40.0	.370	.41	C.
December	95	40	46.5	.431	.50	C.
The year	1,260	40	150	1.39	18.82	

NOTE.—Monthly discharge not computed for 1907-8, as there were several periods when the stage was greater than that for which the rating curve was applicable.

MIDDLE FORK OF HOLSTON RIVER AT CHILHOWIE, VA.

Location.—At iron highway bridge in Chilhowie, about 600 feet south of the Norfolk & Western Railway station.

Drainage area.—144 square miles.

Records available.—June 8, 1907, to December 31, 1909.

Gage.—Chain on highway bridge; read once daily.

Discharge measurements.—Made from highway bridge.

Channel and control.—Right bank overflows at high water. Bed composed of gravel and bowlders. Control fairly permanent.

Extremes of discharge.—Maximum stage recorded: 10.2 feet, June 11, 1907; discharge not computed. Maximum stage may have occurred on other days as gage was not read during extreme floods. Minimum stage recorded: 1.0 foot, November, 1908, and October and November, 1909; discharge, 25 second-feet.

Winter flow.—No information. Discharge relation probably not affected by ice.

Accuracy.—Records fair except for extreme low and high stages.

Coöperation.—Station maintained by United States Geological Survey in coöperation with United States Forest Service.

Discharge measurements of Middle Fork of Holston River at Chilhowie, Va., in 1907–1909.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1907				1908			
June 8	W. E. Hall	4.47	1,780	July 4	F. P. Thomas	1.43	130
Aug. 12	B. M. Hall, Jr.	1.44	112	July 7	do	1.40	146
Aug. 13	W. E. Hall	1.50	140	July 7	W. E. Hall	1.40	144
Aug. 13	Hall and Hall	1.50	141				
Sept. 9	B. M. Hall	1.39	101	1909			
				Mar. 19	W. A. Lamb	1.70	249
1908				Sept. 24	E. H. Swett	1.27	92
Feb. 20	W. E. Hall	1.84	320	Sept. 24	do	1.26	90

Daily gage height, in feet, of Middle Fork of Holston River at Chilhowie, Va., for 1907–1909.

[W. G. Baylor, observer.]

Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907								1907							
1	......	1.6	1.5	1.5	1.4	1.4	1.8	16	2.9	2.2	1.7	1.6	1.5	1.4	1.6
2	......	1.6	1.4	1.4	1.3	1.3	1.7	17	2.5	1.9	1.6	1.5	1.3	1.5	1.8
3	......	1.5	1.5	1.3	1.2	1.2	1.5	18	2.1	1.9	1.7	1.5	1.4	1.6	1.7
4	......	1.5	1.5	1.6	1.4	1.3	1.4	19	2.0	1.8	1.8	1.3	1.3	1.8	1.6
5	......	1.5	1.4	1.4	1.5	1.5	1.6	20	1.9	2.0	1.7	1.3	1.2	1.6	1.5
6	......	1.6	1.5	1.4	1.4	1.4	1.5	21	1.9	1.7	1.5	1.5	1.3	1.4	1.4
7	......	1.6	1.3	1.6	1.6	1.5	1.6	22	1.9	1.7	1.6	1.6	1.4	1.3	1.3
8	......	1.5	1.4	1.4	1.7	1.6	1.8	23	1.9	1.6	1.5	......	1.3	1.5	1.4
9	......	1.5	1.5	1.5	1.4	1.7	1.7	24	1.9	1.6	1.6	2.4	1.3	1.7	1.5
10	2.2	3.05	1.6	1.4	1.3	2.4	1.6	25	1.9	1.5	1.5	1.8	1.4	1.8	1.6
11	10.2	1.8	1.6	1.3	1.4	2.6	1.8	26	1.8	1.7	1.5	1.6	1.3	1.6	1.5
12	3.8	3.6	1.7	1.6	1.5	1.9	1.5	27	1.7	1.9	1.7	1.5	1.4	1.6	1.6
13	......	2.6	1.5	1.4	1.3	1.8	1.6	28	1.6	1.6	1.6	1.3	1.5	1.7	1.9
14	7.5	1.9	1.6	1.6	1.3	1.6	1.4	29	2.0	1.5	1.4	1.4	1.6	1.9	1.5
15	4.3	1.8	1.5	1.4	1.4	1.7	1.5	30	1.8	1.7	1.5	1.3	1.5	2.0	1.6
								31	......	1.6	1.4	......	1.4	......	1.7

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
1	1.4	1.8	2.2	5.1	1.9	1.6	2.7	2.1	2.2	1.3	1.3	1.3
2	1.5	1.9	2.4	5.2	1.9	1.6	2.6	2.4	2.1	1.3	1.3	1.2
3	1.5	2.3	2.2	4.5	1.8	1.6	2.6	2.3	2.1	1.3	1.3	1.2
4	1.6	2.8	2.0	4.0	1.8	3.2	2.6	2.3	2.1	1.3	1.3	1.2
5	2.8	....	2.2	3.4	1.8	2.6	2.6	2.2	2.1	1.3	1.3	1.2
6	2.5	....	3.9	3.4	1.7	2.4	2.6	2.2	2.5	1.3	1.4	1.2
7	2.0	2.9	2.7	3.7	1.7	2.0	2.4	2.1	2.4	1.3	1.4	3.3
8	1.8	2.5	2.5	3.3	1.7	1.8	2.4	2.1	2.4	1.3	1.3	3.5
9	1.5	1.9	2.4	3.0	1.8	1.8	2.4	2.3	2.3	1.3	1.3	3.2
10	1.5	1.8	2.2	2.9	1.6	1.7	2.3	2.7	2.3	1.2	1.3	3.1
11	1.5	1.9	2.1	2.9	1.5	1.7	2.3	2.5	2.2	1.2	1.3	3.1
12	....	1.8	2.15	2.8	1.5	1.7	2.3	2.4	2.2	1.2	1.3	3.0
13	3.2	2.4	2.1	2.8	1.6	1.6	2.2	2.3	2.2	1.2	1.3	2.9
14	2.9	2.8	2.0	2.8	1.6	1.6	2.2	2.3	2.2	1.2	1.3	2.9
15	2.5	2.9	2.0	2.7	1.5	1.6	2.1	2.2	2.2	1.2	1.2	2.7
16	1.9	2.2	2.0	2.7	1.5	1.5	2.1	2.6	2.2	1.2	1.2	2.6
17	1.6	2.0	2.0	2.7	1.4	1.5	2.5	2.4	2.1	1.2	1.2	2.8
18	1.5	2.0	1.9	2.7	1.5	1.4	2.7	2.2	2.1	1.1	1.1	2.7
19	1.5	1.9	1.9	2.3	1.6	1.4	2.6	2.2	2.1	1.2	1.1	2.6
20	1.7	2.0	1.8	2.0	1.7	1.7	2.5	2.2	2.1	1.2	1.1	2.5
21	1.8	1.9	1.8	1.9	1.7	1.8	2.5	2.1	2.1	1.2	1.1	2.5
22	1.5	1.8	1.8	1.8	1.6	1.7	2.4	2.1	2.1	1.2	1.0	2.4
23	1.4	1.8	1.7	1.7	1.6	2.5	2.4	2.1	2.0	1.1	1.0	2.3
24	1.5	1.7	1.7	1.7	1.8	2.1	2.3	2.4	1.9	1.2	1.0	2.3
25	1.5	1.7	1.8	1.7	2.1	1.9	2.3	2.6	1.9	1.2	1.0	2.2
26	1.5	1.8	1.8	2.7	1.9	1.8	2.3	2.7	1.8	1.2	1.0	2.4
27	1.6	1.8	1.8	2.3	1.8	1.7	2.2	2.6	1.7	1.2	1.0	2.4
28	1.7	1.8	1.8	2.2	1.7	1.7	2.2	2.5	1.7	1.4	1.0	3.6
29	1.9	1.7	1.8	2.0	1.7	1.6	2.1	2.5	1.6	1.5	1.0	3.7
30	1.8	....	2.2	2.0	1.8	1.6	2.1	2.4	1.6	1.4	1.3	3.5
31	1.8	....	4.85	....	1.8	....	2.1	2.2	....	1.3	....	3.3

Daily gage height, in feet, of Middle Fork of Holston River at Chilhowie, Va., for 1907–1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
1	2.6	2.5	1.7	1.9	3.4	1.2	1.4	1.3	1.1	1.3	1.0	1.1
2	2.8	2.5	1.7	1.8	2.8	1.2	1.4	2.0	1.1	1.3	1.0	1.1
3	2.2	2.4	1.8	1.8	2.0	1.2	1.3	1.6	1.3	1.3	1.0	1.1
4	2.2	2.5	1.7	1.7	1.8	1.7	1.3	1.4	1.3	1.2	1.0	1.1
5	2.0	2.3	1.9	1.7	1.7	1.6	1.3	1.3	1.2	1.1	1.1	1.1
6	1.9	2.4	2.3	1.7	1.7	1.4	1.3	1.3	1.2	1.1	1.1	1.1
7	1.9	2.2	2.5	1.6	1.7	1.2	1.6	1.3	1.2	1.1	1.1	1.1
8	1.8	2.0	2.2	1.6	1.6	1.2	2.2	1.3	1.2	1.1	1.1	1.2
9	1.7	2.0	2.0	1.5	1.6	1.2	1.8	1.3	1.7	1.1	1.1	1.2
10	1.7	1.8	2.9	1.4	2.8	1.3	1.6	1.4	1.6	1.1	1.1	1.1
11	1.7	1.7	2.3	1.5	2.6	1.3	1.4	1.4	1.5	1.4	1.1	1.1
12	1.7	1.7	2.0	1.5	2.4	1.3	1.3	1.3	1.5	1.4	1.1	1.1
13	1.6	1.6	2.1	1.5	2.0	1.2	1.7	1.3	1.5	1.3	1.1	1.1
14	1.6	1.6	2.4	1.7	2.0	1.2	1.5	1.3	1.4	1.3	1.1	1.3
15	1.5	1.5	2.1	1.7	1.8	1.2	1.4	1.3	1.4	1.3	1.1	1.3
16	2.85	1.5	1.9	1.6	1.6	1.1	1.5	1.2	1.3	1.3	1.1	1.2
17	2.9	1.5	1.8	1.5	1.4	1.1	1.4	1.2	1.3	1.2	1.1	1.2
18	2.7	1.5	1.7	1.5	1.4	1.3	1.3	1.2	1.3	1.2	1.1	1.2
19	2.6	1.8	1.7	1.5	1.3	1.3	1.3	1.2	1.2	1.2	1.1	1.2
20	2.6	2.1	1.6	1.4	1.3	1.4	1.3	1.2	1.2	1.2	1.1	1.2
21	2.4	2.0	2.8	1.4	1.3	1.4	1.4	1.2	1.2	1.2	1.1	1.2
22	2.2	1.9	2.2	1.5	2.4	1.3	1.3	1.1	1.2	1.2	1.1	1.2
23	2.0	1.7	1.9	1.7	2.2	1.2	1.3	1.1	1.2	1.3	1.1	1.2
24	2.0	1.7	1.7	1.6	2.0	1.2	1.3	1.1	1.2	1.2	1.1	1.3
25	1.9	2.7	3.0	1.5	1.8	1.2	1.3	1.1	1.2	1.2	1.1	1.3
26	1.9	2.4	2.4	1.4	1.7	1.2	1.3	1.1	1.2	1.2	1.1	1.3
27	1.9	1.9	2.1	1.4	1.4	1.2	1.3	1.1	1.2	1.1	1.1	1.3
28	1.9	1.7	5.1	1.4	1.7	4.3	1.3	1.1	1.4	1.1	1.1	1.3
29	1.8	....	3.4	1.4	1.8	3.9	1.3	1.1	1.3	1.1	1.1	1.3
30	1.7	....	2.4	7.4	1.6	3.0	1.3	1.1	1.3	1.0	1.1	1.3
31	1.7	....	2.0	....	1.4	....	1.3	1.1	....	1.0	....	1.3

NOTE.—Gage not read on days in 1907-8 for which gage heights are missing.

Daily discharge, in second-feet, of Middle Fork of Holston River at Chilhowie, Va., for 1907–1909.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	....	....	....	....	....	....	208	168	168	132	132	294
2	....	....	....	....	....	....	208	132	132	99	99	250
3	....	....	....	....	....	....	168	168	99	71	71	168
4	....	....	....	....	....	....	168	168	208	132	99	132
5	....	....	....	....	....	....	168	132	132	168	168	208
6	....	....	....	....	....	....	208	168	132	132	132	168
7	....	....	....	....	....	....	208	99	208	208	168	208
8	....	....	....	....	....	....	168	132	132	250	208	294
9	....	....	....	....	....	....	168	168	168	132	250	250
10	....	....	....	....	....	484	952	208	132	99	591	208
11	....	....	....	....	....	....	294	208	99	132	700	294
12	....	....	....	....	....	1,390	1,270	250	208	168	339	168
13	....	....	....	....	....	....	700	168	132	99	294	208
14	....	....	....	....	....	3,820	339	208	208	99	208	132
15	....	....	....	....	....	1,680	294	168	132	132	250	168

Daily discharge, in second-feet, of Middle Fork of Holston River at Chilhowie, Va., for 1907-1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
16	......	......	......	......	......	867	484	250	208	168	132	208
17	......	......	......	......	......	645	339	208	168	99	168	294
18	......	......	......	......	......	433	339	250	168	132	208	250
19	......	......	......	......	......	385	294	294	99	99	294	208
20	......	......	......	......	......	339	385	250	99	71	208	168
21	......	......	......	......	......	339	250	168	168	99	132	132
22	......	......	......	......	......	339	250	208	208	132	99	99
23	......	......	......	......	......	339	208	168	......	99	168	132
24	......	......	......	......	......	339	208	208	591	99	250	168
25	......	......	......	......	......	339	168	168	294	132	294	208
26	......	......	......	......	......	294	250	168	208	99	208	168
27	......	......	......	......	......	250	339	250	168	132	208	208
28	......	......	......	......	......	208	208	208	99	168	250	339
29	......	......	......	......	......	385	168	132	132	208	339	168
30	......	......	......	......	......	294	250	168	99	168	385	208
31	......	......	......	......	......	......	208	132	......	132	......	250
1908												
1	132	294	484	2,160	339	208	250	47	71	47	99	99
2	168	339	591	2,230	339	208	208	132	47	47	99	71
3	168	537	484	1,800	294	208	208	99	47	47	99	71
4	208	811	385	1,510	294	1,040	208	99	47	47	99	71
5	811	830	484	1,150	294	700	208	71	47	47	99	71
6	645	850	1,450	1,150	250	591	208	71	168	47	132	71
7	385	867	755	1,330	250	385	132	47	132	47	132	1,100
8	294	645	645	1,100	250	294	132	47	132	47	99	1,210
9	168	339	591	924	294	294	132	99	99	47	99	1,040
10	168	294	484	867	208	250	99	250	99	71	99	981
11	168	339	433	867	168	250	99	168	71	71	99	981
12	......	294	458	811	168	250	99	132	71	71	99	924
13	1,040	591	433	811	208	208	71	99	71	71	99	867
14	867	811	385	811	208	208	71	99	71	71	99	867
15	645	867	385	755	168	208	47	71	71	71	71	755
16	339	484	385	755	168	168	47	208	71	71	71	700
17	208	385	385	755	132	168	168	132	47	71	71	811
18	168	385	339	755	168	132	250	71	47	47	47	755
19	168	339	339	537	208	132	208	71	47	71	47	700
20	250	385	294	385	250	250	168	71	47	71	47	645
21	294	339	294	339	250	294	168	47	47	71	47	645
22	168	294	294	294	208	250	132	47	47	71	25	591
23	132	294	250	250	208	645	132	47	47	47	25	537
24	168	250	250	250	294	433	99	132	47	71	25	537
25	168	250	294	250	433	339	99	208	47	71	25	484
26	168	294	294	755	339	294	99	250	47	71	25	591
27	208	294	294	537	294	250	71	208	47	71	25	591
28	250	294	294	484	250	250	71	168	47	132	25	1,270
29	339	250	294	385	250	208	47	168	47	168	25	1,330
30	294	......	484	385	294	208	47	132	47	132	99	1,210
31	294	......	2,010	......	294	......	47	71	......	99	......	1,100
1909												
1	700	645	250	339	1,150	71	132	99	47	99	25	47
2	537	645	250	294	811	71	132	385	47	99	25	47
3	484	591	294	294	385	71	99	208	99	99	25	47
4	484	645	250	250	294	250	99	132	99	71	25	47
5	385	537	339	250	250	208	99	99	71	47	47	47
6	339	591	537	250	250	132	99	99	71	47	47	47
7	339	484	645	208	250	71	208	99	71	47	47	47
8	294	385	484	208	208	71	484	99	71	47	47	71
9	250	385	385	168	208	71	294	99	250	47	47	71
10	250	294	867	132	811	99	208	132	208	47	47	47

Daily discharge, in second-feet, of Middle Fork of Holston River at Chilhowie, Va., for 1907–1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
11	250	250	537	168	700	99	132	132	168	132	47	47
12	250	250	385	168	591	99	99	99	168	132	47	47
13	208	208	433	168	385	71	250	99	168	99	47	47
14	208	208	591	250	385	71	168	99	132	99	47	99
15	168	168	433	250	294	71	132	99	132	99	47	99
16	339	168	339	208	208	47	168	71	99	99	47	71
17	867	168	294	168	132	47	132	71	99	71	47	71
18	765	168	250	168	132	99	99	71	99	71	47	71
19	700	294	250	168	99	99	99	71	71	71	47	71
20	700	433	208	132	99	132	99	71	71	71	47	71
21	591	385	811	132	99	132	132	71	71	71	47	71
22	484	339	484	168	591	99	99	47	71	71	47	71
23	385	250	339	250	484	71	99	47	71	99	47	71
24	385	250	250	208	385	71	99	47	71	71	47	99
25	339	755	924	168	294	71	99	47	71	71	47	99
26	339	591	591	132	250	71	99	47	71	71	47	99
27	339	339	433	132	132	71	99	47	71	47	47	99
28	339	250	2,160	132	250	1,680	99	47	132	47	47	99
29	294	....	1,150	132	294	1,450	99	47	99	47	47	99
30	250	....	591	3,750	208	924	99	47	99	25	47	99
31	250	....	385	....	132	....	99	47	....	25	47	99

NOTE.—These daily discharges are based on a rating curve that is fairly well defined between 70 and 2,100 second-feet. There were floods on days for which no discharge is given and gage was not read.

Monthly discharge of Middle Fork of Holston River at Chilhowie, Va., for 1907–1909.

[Drainage area, 144 square miles.]

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1907						
June, 19 days	....	....	693	4.81	3.40	C.
July	1,270	168	318	2.21	2.55	B.
August	294	99	186	1.29	1.49	B.
September, 29 days	....	99	172	1.19	1.28	C.
October	250	71	132	.917	1.06	B.
November	700	71	235	1.63	1.82	B.
December	339	99	205	1.42	1.64	B.
1908						
January, 30 days	....	132	316	2.19	2.44	C.
February	867	250	457	3.17	3.42	B.
March	2,010	250	492	3.42	3.94	A.
April	2,230	250	846	5.88	6.56	A.
May	433	132	251	1.74	2.01	B.
June	1,040	132	311	2.16	2.41	B.
July	250	47	130	.903	1.04	C.
August	250	47	115	.799	.92	C.
September	168	47	65.8	.457	.51	C.
October	168	47	70.5	.490	.56	C.
November	132	25	71.7	.498	.56	B.
December	1,330	71	699	4.85	5.59	A.

Monthly discharge of Middle Fork of Holston River at Chilhowie, Va., for 1907–1909—Continued.

Month	Discharge in second-feet				Run-off (depth in inches on drainage area)	Accuracy
	Maximum	Minimum	Mean	Per square mile		
1909						
January	867	168	419	2.91	3.36	A.
February	755	168	381	2.65	2.76	A.
March	2,160	208	521	3.62	4.17	A.
April	3,750	182	315	2.19	2.44	A.
May	1,150	99	347	2.41	2.78	A.
June	1,680	71	220	1.53	1.71	B.
July	484	99	140	.972	1.12	B.
August	385	47	92.7	.644	.74	B.
September	250	47	102	.708	.79	B.
October	132	25	72.2	.501	.58	C.
November	47	25	44.1	.306	.34	C.
December	99	47	71.5	.497	.57	C.
The year	3,750	25	227	1.58	21.36	

NORTH FORK OF HOLSTON RIVER AT SALTVILLE, VA.

Location.—At highway bridge just below alkali plant on a branch of the Norfolk & Western Railway, about half a mile northwest of Saltville.

Drainage area.—Not measured.

Records available.—June 11, 1907, to November 12, 1908.

Gage.—Chain attached to the highway bridge; read twice daily.

Discharge measurements.—Made from the bridge.

Channel and control.—Left bank high and not likely to overflow. Right bank will overflow at extremely high stages. Bed of stream, gravel. Control practically permanent during 1907-8.

Extremes of discharge.—Maximum stage observed: 12.1 feet at 1 A. M., April 2, 1908; approximate discharge, 6,920 second-feet. Minimum stage observed: 1.5 feet, October 5, 1908; discharge, 33 second-feet.

Winter flow.—No information. Discharge relation probably not affected by ice.

Accuracy.—Results good except possibly for extremely high stages.

Coöperation.—Station maintained by United States Geological Survey in coöperation with United States Forest Service.

Discharge measurements of North Fork of Holston River at Saltville, Va., in 1907–8.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1907							
June 12 ...	W. E. Hall..........	5.86	1,940	Sept. 10..	B. M. Hall, Jr......	1.61	48
Aug. 10...	B. M. Hall, Jr......	2.10	188				
Aug. 14...	.....do	1.97	84	1908			
Aug. 14...	W. E. Hall..........	1.97	94	Feb. 22 ..	W. E. Hall..........	3.35	406
Sept. 10...	B. M. Hall, Jr......	1.61	46	July 3....	F. P. Thomas......	2.29	174
				July 3....	W. E. Hall.........	2.29	177

Daily gage height, in feet, of North Fork of Holston River at Saltville, Va., for 1907–8.

[T. A. Hockett, observer.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	......	......	......	2.55	2.3	2.0	2.9
2	......	......	......	......	......	......	......	......	2.1	2.2	2.4	2.8
3	......	......	......	......	......	......	......	......	2.05	2.1	2.9	2.75
4	......	......	......	......	......	......	......	......	2.0	2.25	2.8	2.55
5	......	......	......	......	......	......	......	......	1.9	2.4	2.55	2.5
6	......	......	......	......	......	......	......	......	1.85	2.5	2.5	2.35
7	......	......	......	......	......	......	......	......	1.8	2.35	2.3	2.3
8	......	......	......	......	......	......	......	......	1.8	2.4	2.8	2.3
9	......	......	......	......	......	......	......	......	1.75	2.25	2.2	2.25
10	......	......	......	......	......	......	......	......	1.7	2.15	5.2	4.6
11	......	......	......	......	......	8.5	......	......	2.3	2.1	4.7	5.9
12	......	......	......	......	......	5.8	......	......	2.5	2.05	4.0	4.3
13	......	......	......	......	......	9.5	......	......	2.35	2.0	3.4	3.7
14	......	......	......	......	......	9.8	......	2.0	2.05	1.95	3.05	3.8
15	......	......	......	......	......	6.0	......	1.9	2.0	1.9	2.8	3.9
16	......	......	......	......	......	4.9	......	1.9	1.9	1.8	2.45	3.8
17	......	......	......	......	......	4.2	......	1.95	1.85	1.8	2.4	3.75
18	......	......	......	......	......	3.85	......	2.45	1.6	1.8	3.6	3.65
19	......	......	......	......	......	3.6	......	2.45	2.75	1.8	3.8	3.35
20	......	......	......	......	......	3.6	......	2.4	2.85	1.8	3.6	3.15
21	......	......	......	......	......	3.5	......	2.1	2.05	1.8	3.55	3.05
22	......	......	......	......	......	3.4	......	2.1	2.55	1.8	3.4	3.0
23	......	......	......	......	......	3.3	......	2.0	5.4	1.8	3.35	2.9
24	......	......	......	......	......	3.8	......	2.25	4.4	1.8	4.6	2.9
25	......	......	......	......	......	3.2	......	2.8	3.35	1.8	4.8	2.75
26	......	......	......	......	......	3.05	......	2.25	3.0	1.8	4.2	2.7
27	......	......	......	......	......	2.9	......	2.2	2.65	1.8	3.8	2.6
28	......	......	......	......	......	2.8	......	2.2	2.5	1.9	3.4	2.6
29	......	......	......	......	......	......	......	2.1	2.5	1.9	3.1	3.45
30	......	......	......	......	......	......	......	2.0	2.4	1.9	3.0	4.4
31	......	......	......	......	......	......	......	2.0	......	1.9	......	5.2
1908												
1	4.0	3.05	3.7	7.9	3.2	3.0	2.6	1.75	1.85	1.6	2.7	......
2	3.65	3.15	5.0	9.7	3.15	2.85	2.4	1.7	1.75	1.6	2.5	......
3	3.2	3.05	4.5	5.9	3.0	2.7	2.35	1.75	1.7	1.6	2.2	......
4	3.2	3.15	4.2	4.9	3.0	4.3	2.3	1.7	1.7	1.55	2.15	......
5	3.5	3.15	4.4	4.2	3.0	5.7	2.45	1.7	2.8	1.5	2.05	......
6	3.15	3.45	6.4	6.0	2.95	4.2	2.55	1.7	3.85	1.55	2.0	......
7	3.05	3.65	5.2	3.65	5.7	3.7	2.45	1.7	2.75	1.55	2.05	......
8	3.65	3.45	4.4	3.5	5.4	3.3	2.3	1.8	2.25	1.6	2.0	......
9	3.35	3.25	4.0	3.4	4.5	3.15	2.15	2.15	2.15	1.65	1.9	......
10	3.0	3.05	3.6	3.3	4.1	2.95	2.1	2.8	2.05	1.65	1.85	......
11	2.7	3.35	3.4	3.35	3.8	2.8	2.0	2.05	2.0	1.9	2.1	......
12	8.6	4.8	3.9	3.55	3.55	2.7	2.0	2.0	1.9	2.45	2.5	......
13	5.4	5.8	3.75	3.4	3.35	2.6	1.9	1.85	1.8	2.15	......	......
14	4.6	6.4	3.8	3.25	3.15	2.6	1.9	1.75	1.75	1.8	......	......
15	4.0	7.6	3.7	3.1	3.0	3.4	2.15	1.7	1.7	1.9	......	......
16	3.85	6.6	3.6	3.1	3.0	3.1	2.25	1.7	1.65	1.7	......	......
17	3.65	4.6	3.5	3.05	2.9	2.85	2.1	1.7	1.6	1.75	......	......
18	3.25	4.2	3.5	3.0	2.8	2.55	2.05	1.75	1.65	1.7	......	......
19	3.15	3.85	3.8	3.0	3.8	2.5	2.0	1.75	1.65	1.75	......	......
20	3.0	3.65	4.6	2.95	4.8	2.45	1.9	1.85	1.65	1.6	......	......
21	3.15	3.25	4.2	2.9	5.0	2.4	1.95	1.7	1.65	1.6	......	......
22	3.25	3.2	4.2	2.85	4.2	3.7	1.95	1.75	1.6	1.55	......	......
23	3.4	3.2	4.2	2.75	3.85	6.6	1.9	1.85	1.6	1.55	......	......
24	3.3	3.0	4.4	2.7	3.5	4.2	1.8	1.9	1.55	1.6	......	......
25	3.15	3.0	4.5	2.9	3.2	3.35	1.8	1.95	1.55	1.55	......	......

Daily gage height, in feet, of North Fork of Holston River at Saltville, Va., for 1907–8—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
26	2.95	3.2	4.0	5.2	2.95	3.1	1.85	2.15	1.55	2.0	......	......
27	3.85	3.1	3.8	4.0	3.4	2.85	1.9	2.4	1.6	1.9	......	......
28	3.65	2.95	3.5	3.4	3.25	2.55	1.8	2.1	1.65	1.8	......	......
29	3.65	2.9	3.4	3.35	3.25	2.5	1.85	2.0	1.65	2.25	......	......
30	3.25	......	3.4	3.2	3.6	2.7	1.8	1.9	1.65	3.7	......	......
31	3.05	......	3.4	......	3.25	......	1.8	1.9	......	3.25	......	......

NOTE.—Gage destroyed or stolen on night of June 28, 1907, replaced Aug. 14, 1907. Gage stolen Nov. 13, 1908, and station discontinued.

Daily discharge, in second-feet, of North Fork of Holston River at Saltville, Va., for 1907–8.

Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907								1907							
1	......	......	......	210	160	106	290	16	1,200	......	90	90	75	190	580
2	......	......	......	123	141	180	266	17	770	......	98	82	75	180	560
3	......	......	......	114	123	290	254	18	602	......	190	46	75	500	520
4	......	......	......	106	150	266	210	19	500	......	190	254	75	580	415
5	......	......	......	90	180	210	200	20	500	......	180	170	75	500	355
6	......	......	......	82	200	200	170	21	465	......	123	114	75	482	328
7	......	......	......	75	170	160	160	22	430	......	123	210	75	430	315
8	......	......	......	75	180	160	160	23	400	......	106	1,560	75	415	290
9	......	......	......	68	150	141	150	24	580	......	150	880	75	1,000	290
10	......	......	......	60	132	1,420	1,000	25	370	......	160	415	75	1,130	254
11	4,040	......	......	160	123	1,060	1,960	26	328	......	150	315	75	770	243
12	1,880	......	......	200	114	670	825	27	290	......	141	232	75	580	221
13	4,840	......	......	170	106	430	540	28	266	......	141	200	90	430	221
14	5,080	......	106	114	98	328	580	29	......	......	123	200	90	340	448
15	2,040	......	90	106	90	266	625	30	......	......	106	180	90	315	880
								31	......	......	106	......	90	......	1,420

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
1	670	328	540	3,560	370	315	221	68	82	46	243	......
2	520	355	1,270	5,000	355	278	180	60	68	46	200	......
3	370	328	940	1,960	315	243	170	68	60	46	141	......
4	370	355	770	1,200	315	825	160	60	60	40	132	......
5	465	355	880	770	315	1,800	190	60	266	33	114	......
6	355	448	2,360	670	302	770	210	60	602	40	106	......
7	328	520	1,420	520	1,800	540	190	60	254	40	114	......
8	520	448	880	465	1,560	400	160	75	150	46	106	......
9	415	385	670	430	940	355	132	132	132	53	90	......
10	400	328	500	400	720	302	123	160	114	53	82	......
11	243	415	430	415	580	266	106	114	106	90	123	......
12	4,120	1,130	625	428	482	243	106	106	90	190	200	......
13	1,560	1,880	560	430	415	221	90	82	75	132	......	......
14	1,000	2,360	580	385	355	221	90	68	68	75	......	......
15	670	3,320	540	340	315	430	132	60	60	90	......	......

Daily discharge, in second-feet, of North Fork of Holston River at Saltville, Va., for 1907–8—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
16	602	2,520	500	340	315	340	150	60	53	60	......	......
17	520	1,000	465	328	290	278	123	60	46	68	......	......
18	385	770	465	315	266	210	114	68	53	60	......	......
19	355	602	580	315	580	200	106	68	53	68	......	......
20	315	520	1,000	302	1,130	190	90	82	53	46	......	......
21	355	385	770	290	1,270	180	98	60	53	46	......	......
22	385	370	770	278	770	540	98	68	46	40	......	......
23	430	370	770	254	602	2,520	90	82	46	40	......	......
24	400	315	880	243	465	770	75	90	40	46	......	......
25	355	315	940	290	370	415	75	98	40	40	......	......
26	302	370	670	1,420	302	340	82	132	40	106	......	......
27	602	340	580	670	430	278	90	180	46	90	......	......
28	520	302	465	430	385	210	75	123	53	75	......	......
29	520	290	430	415	385	200	82	106	53	150	......	......
30	385	......	430	370	500	243	75	90	53	540	......	......
31	328	......	430	......	385	......	75	90	......	385	......	......

NOTE.—Discharge determined from a rating curve fairly well defined below 2,500 second-feet.

Monthly discharge of North Fork of Holston River at Saltville, Va., for 1907–8.

Month	Discharge in second-feet			Accuracy
	Maximum	Minimum	Mean	
1907				
June 11–28	5,080	266	1,370	B.
August 14–31	190	90	132	B.
September	1,560	46	223	B.
October	200	75	109	B.
November	1,420	106	458	B.
December	1,960	150	475	B.
1908				
January	4,120	243	605	B.
February	3,320	290	739	B.
March	2,360	430	745	B.
April	5,000	243	776	B.
May	1,800	266	567	B.
June	2,520	180	471	B.
July	221	75	121	B.
August	180	60	86.8	B.
September	602	40	97.2	B.
October	540	33	92.9	B.
November 1–12	243	82	138	B.

CLINCH RIVER AT CLINCHPORT, VA.

Location.—About 500 feet above the Virginia & Southwestern Railway bridge at Clinchport, a short distance below mouth of Stock Creek, and about 1½ miles above Copper Creek.

Drainage area.—Not measured.

Records available.—June 7, 1907, to December 31, 1909.

Gage.—Vertical staff spiked to sycamore tree on right bank; read once daily.

Discharge measurements.—Made from railroad bridge.

Channel and control.—Banks high and not likely to overflow; bed composed of rock and mud. Control changes slightly.

Extremes of discharge.—Maximum stage recorded: 19.5 feet, June 14, 1907; discharge not computed. Minimum stage recorded: 0.4 foot in November and December, 1909; discharge, 134 second-feet.

Winter flow.—No information. Discharge relation probably not affected by ice.

Accuracy.—Records fair.

Coöperation.—Station maintained by United States Geological Survey in coöperation with the United States Forest Service.

Discharge not estimated for high stages because of lack of discharge measurements.

Discharge measurements of Clinch River at Clinchport, Va., in 1907–1909.

Date	Made by	Gage height	Discharge	Date	Made by	Gage height	Discharge
		Feet	*Sec.-ft.*			*Feet*	*Sec.-ft.*
1907				1908			
Aug. 15...	W. E. Hall.........	1.30	757	July 2....	F. P. Thomas......	1.14	664
Aug. 15...	B. M. Hall, Jr.....	1.30	734	July 2....	W. E. Hall.........	1.14	655
Sept. 7....	.....do	.81	430				
				1909			
1908				Sept. 22..	E. H. Swett........	.70	275
Feb. 24 ...	W. E. Hall.........	2.10	1,530				

Daily gage height, in feet, of Clinch River at Clinchport, Va., for 1907–1909.

[C. R. Lane and J. W. Morrison, observers.]

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	......	......	......	......	......	......	1.9	1.6	0.8	1.0	0.7	1.9
2	......	......	......	......	......	......	1.5	2.6	.9	.9	.9	1.7
3	......	......	......	......	......	......	1.3	1.6	1.2	.8	2.5	1.6
4	......	......	......	......	......	......	1.2	1.4	1.4	.8	1.9	1.5
5	......	......	......	......	......	......	1.1	1.1	1.0	.9	1.5	1.4
6	......	......	......	......	......	......	1.0	1.4	.9	1.0	1.3	1.3
7	......	......	......	......	......	2.0	1.2	1.9	.8	1.0	1.2	1.2
8	......	......	......	......	......	2.3	1.1	1.7	1.0	1.1	1.2	1.1
9	......	......	......	......	......	7.2	1.0	1.7	.9	1.1	1.1	1.1
10	......	......	......	......	......	4.6	1.0	2.0	.8	1.0	4.2	1.3
11	......	......	......	......	......	4.8	1.1	1.5	1.6	.9	10.0	1.8
12	......	......	......	......	......	8.5	1.2	1.3	1.4	.8	4.9	3.1
13	......	......	......	......	......	5.6	1.6	1.2	1.3	.8	3.4	2.5
14	......	......	......	......	......	18.8	2.2	1.8	1.2	.8	2.7	2.2
15	......	......	......	......	......	10.0	2.0	1.4	1.0	.7	2.3	2.1
16	......	......	......	......	......	5.6	1.6	1.2	.9	.7	1.9	2.3
17	......	......	......	......	......	4.2	1.5	1.3	.8	.7	1.7	2.1
18	......	......	......	......	......	3.3	1.3	2.7	.8	.6	1.8	2.0
19	......	......	......	......	......	2.9	1.2	3.0	.7	.6	2.6	1.9
20	......	......	......	......	......	2.6	1.1	2.2	.7	.6	2.9	1.7
21	......	......	......	......	......	2.3	1.0	2.1	.7	.6	2.6	1.6
22	......	......	......	......	......	2.2	.9	1.7	1.3	.6	2.3	1.5
23	......	......	......	......	......	1.9	.8	1.6	2.1	.6	2.1	2.2
24	......	......	......	......	......	1.9	.8	1.5	2.3	.6	8.0	3.7
25	......	......	......	......	......	2.0	1.7	1.5	2.1	.6	6.5	3.4
26	......	......	......	......	......	1.7	1.6	1.4	1.6	.5	4.5	2.8
27	......	......	......	......	......	1.6	1.4	1.4	1.3	.6	3.5	2.4
28	......	......	......	......	......	1.4	1.7	1.2	1.1	.7	2.9	2.2
29	......	......	......	......	......	1.2	1.3	1.1	1.1	.6	2.5	2.0
30	......	......	......	......	......	2.9	2.2	1.0	1.0	.6	2.1	4.5
31	......	......	......	......	......	......	1.9	.9	......	.6	......	7.3
1908												
1	4.7	2.2	3.0	2.8	2.0	1.9	1.2	.8	.6	.5	1.4	1.4
2	3.7	2.9	4.3	11.3	1.9	1.5	1.2	.7	.6	.5	1.1	1.3
3	3.1	2.4	4.5	8.2	1.9	1.4	1.1	.6	.5	.5	1.0	1.3
4	2.6	2.2	3.8	5.6	1.9	1.3	1.0	.6	.5	.5	.8	1.4
5	3.3	2.3	3.4	4.2	1.8	1.6	1.0	.6	.6	.4	.8	1.4
6	4.0	3.5	6.6	3.5	1.9	2.5	1.0	.6	3.0	.4	.7	1.3
7	3.5	4.9	5.9	3.1	2.3	1.9	1.2	.8	3.7	.4	.7	2.5
8	3.1	4.2	4.4	2.7	3.1	1.6	1.6	.8	2.3	.4	.6	4.3
9	2.7	3.4	3.5	2.5	2.8	1.4	1.2	1.0	1.7	.4	.6	3.9
10	2.3	2.9	3.2	2.3	2.5	1.3	1.1	1.1	1.3	.7	.6	2.7
11	2.1	3.2	2.8	2.2	2.2	1.3	1.0	1.6	1.1	1.1	.7	2.2
12	3.9	3.7	3.4	2.3	2.0	1.2	.9	1.1	1.0	.8	1.5	3.3
13	7.4	5.2	3.9	2.5	1.8	1.1	.8	.9	.9	.7	1.7	3.4
14	4.9	5.5	3.7	2.3	1.7	1.0	.8	.8	.8	.6	1.4	2.9
15	3.7	6.9	3.4	2.2	1.5	1.1	1.6	.7	.8	.6	1.3	2.6
16	3.3	8.0	3.1	2.1	1.5	3.6	1.0	.8	.7	.6	1.2	2.2
17	2.9	5.4	2.9	2.0	1.4	2.5	1.2	.8	.7	.5	1.2	1.9
18	2.7	4.1	4.7	1.9	1.4	1.8	1.0	1.2	.7	.4	1.2	1.7
19	2.5	3.4	3.7	1.9	1.4	1.4	1.0	1.5	.6	.4	1.3	1.6
20	2.3	3.0	5.0	1.9	1.9	1.2	.9	1.2	.6	.4	1.3	1.6
21	2.2	2.7	4.9	1.8	3.2	1.6	.8	1.1	.6	.4	1.3	1.6
22	2.1	2.4	4.3	1.7	2.7	1.7	.7	1.9	.6	.4	1.2	1.7
23	2.1	2.2	4.2	1.6	2.4	7.7	.7	2.2	.6	.5	1.1	5.0
24	2.0	2.1	4.6	1.5	2.2	3.7	.6	1.7	.5	.7	1.0	4.2
25	1.9	2.0	4.9	1.7	2.1	2.8	.7	1.3	.5	1.0	1.0	3.4

Daily gage height, in feet, of Clinch River at Clinchport, Va., for 1907–1909—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908												
26	1.8	2.2	4.1	4.2	2.0	2.1	.7	1.0	.5	.8	.9	3.7
27	2.3	2.8	3.4	3.6	1.9	1.7	.7	.9	.5	.7	.9	5.0
28	3.7	2.6	3.0	2.9	1.9	1.5	.7	.8	.5	.7	.8	3.6
29	3.1	2.4	2.7	2.4	2.0	1.3	.7	.8	.5	.9	.8	3.0
30	2.6	....	2.6	2.1	2.9	1.3	1.1	.8	.5	1.1	.9	2.8
31	2.2	....	2.4	....	2.4	....	1.0	.7	....	1.3	....	3.0
1909												
1	3.1	1.4	2.9	3.1	9.0	1.0	2.8	2.3	0.8	0.6	0.6	0.4
2	3.0	1.3	2.5	2.7	8.5	1.3	2.5	3.2	.8	.6	.6	.4
3	2.6	1.6	2.3	2.5	6.7	1.1	2.3	3.0	.7	.6	.6	.4
4	2.3	1.5	2.4	2.2	4.3	3.3	1.5	2.3	.6	.6	.6	.4
5	2.4	1.5	2.4	2.0	3.8	2.8	1.4	1.6	.5	.5	.6	.4
6	2.9	1.7	3.9	1.9	3.0	2.3	1.3	1.6	.5	.5	.6	.4
7	2.7	2.0	4.5	1.9	2.6	1.9	1.4	1.5	.5	.5	.6	.4
8	2.4	2.2	4.4	2.0	2.4	1.6	1.3	1.5	.7	.5	.6	.5
9	2.2	2.2	3.7	1.8	2.1	3.3	3.5	1.4	.7	.5	.5	.5
10	2.0	6.3	5.9	1.7	2.7	4.8	3.0	1.2	.7	.5	.5	.5
11	1.8	6.6	7.7	1.6	3.2	3.5	2.3	1.1	.7	.5	.5	.5
12	1.7	4.4	5.0	1.5	3.0	3.3	2.1	1.0	.9	.5	.5	.5
13	1.6	3.4	4.0	1.4	2.7	3.0	2.5	1.0	.7	.5	.5	.8
14	1.6	2.9	4.5	1.5	2.3	6.5	5.3	1.0	.6	.5	.4	.8
15	2.9	2.7	4.2	1.5	2.1	5.6	4.1	1.0	.6	.6	.4	.8
16	4.0	3.8	3.7	1.5	1.9	4.2	2.9	2.5	.6	.6	.4	.6
17	6.2	4.5	3.2	1.4	1.8	3.8	5.9	2.5	.8	.6	.4	.6
18	5.3	3.8	2.8	1.3	1.7	3.5	3.9	2.3	.7	.6	.4	.5
19	4.1	3.2	2.5	1.2	1.5	3.2	2.4	2.1	.6	.6	.4	.5
20	3.3	3.7	2.3	1.2	1.5	2.0	2.0	2.6	.6	.6	.4	.5
21	2.8	3.4	2.2	1.4	1.7	2.1	1.6	1.3	.6	.6	.4	.5
22	2.4	3.5	2.1	1.9	1.6	1.9	1.5	1.0	.8	.6	.4	.5
23	2.2	5.0	2.5	2.8	1.5	2.3	1.4	1.0	.8	.6	.4	.5
24	2.0	3.6	2.3	4.0	1.4	2.6	1.4	.8	.8	.6	.4	.5
25	1.8	6.5	3.6	3.5	1.4	3.2	1.3	1.1	.7	.6	.4	.5
26	1.8	5.3	6.2	2.8	1.3	2.6	1.2	1.1	.6	.6	.4	.5
27	2.1	4.1	4.7	2.5	1.4	2.0	1.3	.8	.6	.6	.4	.5
28	2.1	3.4	5.8	2.2	1.2	2.3	1.3	1.0	.6	.6	.4	.5
29	2.0	....	6.8	2.0	1.2	2.1	1.2	.8	.6	.6	.4	.5
30	1.9	....	4.9	2.3	1.1	2.4	1.2	.8	.6	.6	.4	.5
31	1.8	....	3.8	....	1.1	....	1.4	.8	....	.6	....	.5

Daily discharge, in second-feet, of Clinch River at Clinchport, Va., for 1907–1909.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
1	....	....	....	....	....	....	1,310	1,010	420	545	360	1,310
2	....	....	....	....	....	....	920	....	480	480	480	1,100
3	....	....	....	....	....	....	755	1,010	680	420	2,050	1,010
4	....	....	....	....	....	....	680	835	835	420	1,310	920
5	....	....	....	....	....	....	610	610	545	480	920	835
6	....	....	....	....	....	....	545	835	480	545	755	755
7	....	....	....	....	....	1,420	680	1,310	420	545	680	680
8	....	....	....	....	....	1,780	610	1,100	545	610	680	610
9	....	....	....	....	....	....	545	1,100	480	610	610	610
10	....	....	....	....	....	....	545	1,420	420	545	....	755

Daily discharge, in second-feet, of Clinch River at Clinchport, Va., for 1907–1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907												
11	......	......	......	......	......	......	610	920	1,010	480	......	1,200
12	......	......	......	......	......	......	680	755	835	420	......	......
13	......	......	......	......	......	......	1,010	680	755	420	......	2,050
14	......	......	......	......	......	......	1,660	1,200	680	420	......	1,660
15	......	......	......	......	......	......	1,420	835	545	360	1,780	1,540
16	......	......	......	......	......	......	1,010	680	480	360	1,310	1,780
17	......	......	......	......	......	......	920	755	420	360	1,100	1,540
18	......	......	......	......	......	......	755	......	420	305	1,200	1,420
19	......	......	......	......	......	......	680	......	360	305	......	1,310
20	......	......	......	......	......	......	610	1,660	360	305	......	1,100
21	......	......	......	......	......	1,780	545	1,540	360	305	......	1,010
22	......	......	......	......	......	1,660	480	1,100	755	305	1,780	920
23	......	......	......	......	......	1,310	420	1,010	1,540	305	1,540	1,660
24	......	......	......	......	......	1,310	420	920	1,780	305	......	......
25	......	......	......	......	......	1,420	1,110	920	1,540	305	......	......
26	......	......	......	......	......	1,100	1,010	835	1,010	250	......	......
27	......	......	......	......	......	1,010	835	835	755	305	......	1,910
28	......	......	......	......	......	835	1,100	680	610	360	......	1,660
29	......	......	......	......	......	680	755	610	610	305	2,050	1,420
30	......	......	......	......	......	......	1,660	545	545	305	1,540	......
31	......	......	......	......	......	......	1,310	480	......	305	......	......
1908												
1	......	1,660	......	......	1,420	1,310	680	420	305	250	835	835
2	......	......	......	......	1,310	920	680	360	305	250	610	1,200
3	......	1,910	......	......	1,310	835	610	305	250	250	545	1,200
4	......	1,660	......	......	1,310	755	545	305	250	250	420	835
5	......	1,780	......	......	1,200	1,010	545	305	305	200	420	835
6	......	......	......	......	1,310	2,050	545	305	......	200	360	755
7	......	......	......	......	1,780	1,310	680	420	......	200	360	2,050
8	......	......	......	......	......	1,010	1,010	420	1,780	200	305	......
9	......	......	......	2,050	......	835	680	545	1,100	200	305	......
10	1,780	......	......	1,780	2,050	755	610	610	755	360	305	......
11	1,540	......	......	1,660	1,660	755	545	1,010	610	610	360	1,660
12	......	......	......	1,780	1,420	680	480	610	545	420	920	......
13	......	......	......	2,050	1,200	610	420	480	480	360	1,100	......
14	......	......	......	1,780	1,100	545	420	420	420	305	835	......
15	......	......	......	1,660	920	610	1,010	360	420	305	755	......
16	......	......	......	1,540	920	......	545	420	360	305	680	1,660
17	......	......	......	1,420	835	2,050	680	420	360	250	680	1,310
18	......	......	......	1,310	835	1,200	545	680	360	200	680	1,100
19	2,050	......	......	1,310	835	835	545	920	305	200	755	1,010
20	1,780	......	......	1,310	1,310	680	480	680	305	200	755	1,010
21	1,660	......	......	1,200	......	1,010	420	610	305	200	755	1,010
22	1,540	1,910	......	1,100	......	1,100	360	1,310	305	200	680	1,100
23	1,540	1,660	......	1,010	1,910	......	360	1,660	305	250	610	......
24	1,420	1,540	......	920	1,660	......	305	1,100	250	360	545	......
25	1,310	1,420	......	1,100	1,540	......	360	755	250	545	545	......
26	1,200	1,660	......	......	1,420	1,540	360	545	250	420	480	......
27	1,780	......	......	......	1,310	1,100	360	480	250	360	480	......
28	......	......	......	......	1,310	920	360	420	250	360	420	......
29	......	1,910	......	1,910	1,420	755	360	420	250	480	420	......
30	......	......	......	1,540	......	755	610	420	250	610	480	......
31	1,660	......	1,910	......	1,910	......	545	360	......	755	......	......
1909												
1	......	750	......	......	......	455	......	1,680	330	225	255	134
2	......	670	1,920	......	......	670	1,920	......	330	225	225	134
3	......	925	1,680	1,920	......	525	1,680	......	275	225	225	134
4	1,680	835	1,800	1,560	......	......	835	1,680	225	225	225	134
5	1,800	835	1,800	1,340	......	......	750	925	178	178	225	134

Daily discharge, in second-feet, of Clinch River at Clinchport, Va., for 1907–1909—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
6	....	1,020	....	1,230	....	1,680	670	925	178	178	225	134
7	....	1,340	....	1,230	....	1,230	750	835	178	178	225	134
8	1,800	1,560	....	1,340	1,800	925	670	835	275	178	225	178
9	1,560	1,560	....	1,120	1,450	....	....	750	275	178	178	178
10	1,340	....	....	1,020	....	....	....	595	275	178	178	178
11	1,120	....	....	925	....	....	1,680	525	275	178	178	178
12	1,020	....	....	835	....	....	1,450	455	390	178	178	178
13	925	....	....	750	....	....	1,920	455	275	178	178	330
14	925	....	....	835	1,680	....	....	455	225	178	134	330
15	....	....	....	835	1,450	....	....	455	225	225	134	330
16	....	....	....	835	1,230	....	....	1,920	225	225	134	225
17	....	....	....	750	1,120	....	....	1,920	330	225	134	225
18	....	....	....	670	1,020	....	....	1,680	275	225	134	178
19	....	....	1,920	595	835	....	1,800	1,450	225	225	134	178
20	....	....	1,680	595	835	1,340	1,340	....	225	225	134	178
21	....	....	1,560	750	1,020	1,450	925	670	225	225	134	178
22	1,800	....	1,450	1,230	925	1,230	835	455	330	225	134	178
23	1,560	....	1,920	....	835	1,680	750	455	330	225	134	178
24	1,340	....	1,680	....	750	....	750	330	330	225	134	178
25	1,120	....	....	....	750	....	670	525	275	225	134	178
26	1,120	....	....	....	670	....	595	525	225	225	134	178
27	1,450	....	....	1,920	750	1,340	670	330	225	225	134	178
28	1,450	....	....	1,560	595	1,680	670	455	225	225	134	178
29	1,340	....	....	1,340	595	1,450	595	330	225	225	134	178
30	1,230	....	....	1,680	525	1,800	595	330	225	225	134	178
31	1,120	....	....	....	525	....	750	330	....	225	....	178

NOTE.—These discharges are based on rating curves which are applicable as follows: June 7, 1907, to December 31, 1908, well defined between discharges 200 and 1,600 second-feet; January 1 to December 31, 1909, not well defined. For all missing days June 7, 1907, to December 31, 1908, the discharge was greater than 2,100 second-feet. For all missing days January 1 to December 31, 1909, the discharge was greater than 1,900 second-feet.

INDEX

VIRGINIA GEOLOGICAL SURVEY
UNIVERSITY OF VIRGINIA
THOMAS LEONARD WATSON, PH. D.
DIRECTOR

Bulletin No. X

Surface Water Supply of Virginia

BY

G. C. STEVENS

PREPARED IN COOPERATION WITH THE
UNITED STATES GEOLOGICAL SURVEY

CHARLOTTESVILLE
UNIVERSITY OF VIRGINIA
1916